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ABSTRACT

The purpose of this collection of five essays is to present a sample of the diverse directions taken by economists in their analysis of education. Topics discussed include the effects of earnings on human capital formation; the production function and its use in the study of education; goals and accountability; domestic educational finance and the international study of macroeducational planning; and human capital formation beyond the traditional educational sector. (Author/LD)

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ECONOMIC DIMENSIONS OF EDUCATION

**REPORT OF
A COMMITTEE OF
THE NATIONAL ACADEMY
OF EDUCATION**

May 1979

EA 012 301

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EDITOR'S INTRODUCTION

THE PURPOSE of this collection of essays is to present a sample of the diverse directions being taken by economists in their analysis of education. The most obvious conclusion to be made from these essays—and from the larger bodies of work upon which they draw—is that it is foolish to continue to talk about *the* economics of education as if any monolithic conceptual structure existed. The diversity among economists studying education has meant that the discipline often has presented a confusing mixture of policy suggestions to practitioners. Not surprisingly, practitioners, faced by contradictory or even mutually exclusive prescriptions, have been slow to accept the economists' interest in this field of work as an unmixed blessing.

The essays presented here are in no way an attempt to force any artificial consensus. Rather, the only limitation placed was in assuring that the authors' experience, research and writing skills, and professional standing were such that policy content could be analyzed without undue concern for the quality of the work itself. The five essays are therefore designed as a sampler for some and as guides to the frontiers of research for others. While the authors as well as the editor have tried to minimize economic jargon and mathematical complexity, we have always sided with precision of presentation over any artificially induced attempt to place the discussion in the vernacular.

The essays have been organized so as to facilitate the introduction of this field to those new to the economics of education. Professor Mincer's article presents a valuable survey of the research into human capital formation and its effects on earnings. Many of the concepts and issues raised in the Mincer article are returned to in the following essays. Professor Lau's treatment of the production function and its use in the study of education is especially timely. The use of various forms of input/output analysis in the evaluation of education is under serious attack at present. Professor Lau has done an excellent job of laying out the inherent weaknesses of the production function approach and has explained why it still has a role, albeit a more limited one than in the recent past, in policy analysis of education.

Professor Chambers has had the courage to attempt to break through the problem of output specification in education—to try to specify certain goals so that accountability can be introduced into the

administrative process. Given that education remains a predominantly public enterprise with limited opportunities for consumer control, an accountability system is required if the important decisions concerning education are not to be left solely to the educational bureaucracy itself. The essay which is presented here is full evidence that Professor Chamber's confidence was justified. It may be expected that this work will help redirect much of the research in this area for some time to come.

My own essay represents an opportunity to draw together two heretofore diverse directions of my research and writing. For the last five years my work has been divided between and analysis of domestic higher education finance and the international study of macroeducational planning. The present essay weaves the concepts that I have found to be common to these two endeavors.

The essay collection concludes with an exceptionally fine piece by Professor Bowman on the formation of human capital beyond the traditional educational sector. This redirection of interest is one in which Professor Bowman has been a leader and it offers valuable insights for all of us interested in alternative structures for learning opportunities.

While five essays can do little more than suggest the rich diversity of the economics of education, it is hoped the readers will be encouraged by these works to explore further on their own. While the economist's position in educational analysis may be new and controversial, there is little doubt that it will be an increasingly important one in the foreseeable future.

Undoubtedly all that we do is shaped by our environment, but I would like to take this opportunity to thank two particular parts of that environment: Ms. Nancy Ward, who is simultaneously patient, exacting, and hardworking and who excels at making impossible tasks quite probable; and Ms. Jeannette Windham, whose editorial assistance has been invaluable and whose affection and support are indispensable.

And in addition to the authors, without whom editors would find their skills little called for, I must extend special thanks to Ms. Bonnie Senko and Mr. William Hyde for their liaison activities on the part of the National Academy of Education. Their understanding of and consideration for the creative problems of authors made this whole task much more pleasant.

Chapter 1

HUMAN CAPITAL AND EARNINGS

JACOB MINCER

Columbia University

HUMAN capital is an old concept but a relatively new research area in economics. The central idea is that human capacities are in large part acquired or developed through informal and formal education at home and at school, and through training, experience, and mobility in the labor market. These activities are costly, as they involve direct expenses and earnings or consumption forgone by students, by trainees, and by workers in the process of labor mobility. Since benefits derived from these activities accrue mainly in the future and are for the most part quite durable, the costly acquisition of human capacities is an act of investment. Deterioration of health and erosion or obsolescence of skills represent depreciation of human capital which is offset, though not indefinitely, by maintenance activities such as the production of health or retraining.

As Adam Smith pointed out long ago, the notions involved in investments in human resources are basically the same as the concepts in the economics of physical capital investments. It follows that the standard tools of economic analysis can be applied to a wide range of human activities whether or not the activities take on forms of explicit market transactions. This realization is a welcome step toward the obliteration of traditional boundaries among the several fields of behavioral science. In the field of education, as in other fields, such steps have been taken only very recently. Whether it was intellectual fear of economic reductionism or emotional resentment against treating labor "as machine" that inhibited progress, the emergence of modern analytical and econometric research in human capital is not more than two decades old. But its growth into a veritable avalanche can be seen in the exploding volume of bibliographical references.

The sprawling research literature has rapidly outgrown the capacity of a single individual to comprehend and to survey it. My task is somewhat more manageable, since this survey is restricted to studies of effects of human capital on earnings. Note, however, that the concept of human capital is broader than school education and cannot be reduced to the latter for analytical purposes: Since schooling is one among several and related forms of human capital, its effects cannot be isolated when these other forms are ignored.

The general categories of human capital investments can be described in a life-cycle chronology. Resources in child care and child development represent preschool investments. These overlap and are followed by investments in formal school education. Investments in labor market mobility, job choice, job training, and work effort occur during the working life, while investments in health and other maintenance activities continue throughout life.

SCHOOL EDUCATION

Initially, investment in school education received almost exclusive attention from human capital analysts. While economists since Smith have recognized the importance of education as a type of private or social investment, only recently have economists undertaken rigorous conceptual and statistical examination of the evidence on costs, benefits, and rates of return to education.

The costs of education borne by the student or his parents consist not merely of tuition and other school expenditures but also of forgone earnings—the loss of what the student could have earned if he had spent the school years in gainful employment. Beyond early schooling, forgone earnings are the largest component (over one-half) of schooling costs.

Investors in schooling envisage flows of earnings in the labor market that correspond to each schooling level. The discounted difference between the future flows with and without additional schooling—namely, the present value of the return on the additional investment in schooling—represents the gain or loss on the investment. Gains induce further schooling and losses discourage it. Of course, the discounted difference between the future flows (the gain or the loss) depends on the size of the relevant discount rate: the interest rate at which the individual can borrow or which he can earn elsewhere on the funds he would invest in education. Unfortunately, such individual discount rates are not observable.

An alternative way to represent this decision-making process is to calculate the internal rate of return on the investment—that hypothet-

ical rate of interest which will make the profit equal to zero and, thus, the investment just about worthwhile. Further schooling is encouraged if the internal rate of return on schooling exceeds the rate of alternative investments. This method is more useful, since internal rates of return can be calculated given estimates of costs and of typical earnings streams.

Comparison of rates of return to education with rates of return on other (say, in business capital) investments not only can explain flows into the respective fields, but also can indicate the desirability of existing allocations or changes in relative allocations of investments from society's point of view—provided estimates of social costs and social returns can be formed.

It is understood, of course, that relevant concepts of costs and benefits are real, that is, not restricted to pecuniary terms: Education itself may be desirable for its own sake and it may enhance future enjoyment of life, apart from the monetary gain. Since people differ in these attitudes and perceptions, different monetary gains (or losses) for different individuals may correspond to the same real rate of return.

More generally, variation in observed individual monetary returns to educational investments is partly due to individual differences, not only in nonpecuniary aspects of education (consumption components), but also in efficiency in absorbing education, and to individual differences in discount rates. These in turn result from differences in preferences between the present and the future and from differential access to financing of such investments.

But why do employers pay higher wages to the more educated workers, on average? Evidently, the value productivity of the better educated worker is seen and experienced as higher than that of the less educated worker. Now, an increased supply of educated workers reduces the marginal value product, while increased wage differentials induce a greater supply. Hence, relative supplies are stabilized at levels at which the wage differential translates into rates of return comparable to those on alternative human or nonhuman investments. Increases in demand favoring more educated workers raise the rate of return on schooling, inducing growth of enrollments until the increased return has been eliminated by the increased supply of the more educated workers. This appears to be the history of U.S. education in the past three decades, at least up to 1970.

Initially, analyses of effects of education on earnings were carried out by estimating direct and forgone costs of a given increment of schooling and discounting the differentials between earnings profiles of workers with the higher and lower levels of schooling. These

procedures, utilizing decennial census data on annual earnings, produced a variety of estimates. Most estimates showed rates of return comparable to rates on business investments, though higher at lower levels of schooling, and rather stable between 1950 and 1970. The rates were permanently higher prior to World War II and have temporarily declined in the 1970s (Becker, 1975; Chiswick & Mincer, 1972; Freeman, 1976).

The calculations that are available do not include nonpecuniary or "consumption components" of costs or of returns. To the extent that these are positive and important in the benefits of schooling (an assumption dear to the hearts of educators), the rates are underestimated, though the pattern of their historical changes need not be affected. Distinctions are also made between private and social rates. In calculating private rates, costs and returns to students and their families are computed from after-tax data, and schooling costs do not include public financing of schools. In contrast, the calculation of social cost is based on before-tax earnings, and school costs are the total costs of the relevant school system (per student) regardless of the source of financing. The difficulty in calculating true social rates of return is the problem of measuring externalities. To the extent that the gain to society exceeds the sum of gains to students, social returns are underestimated. Again, an assumption of public policy dear to educators, though less readily accepted today than in the past by policymakers, is that such educational externalities are substantial and positive. This is an important, if almost unverifiable, economic justification of public support to education, though it is hardly an explanation of the public ownership of schools.

EARNINGS PROFILES

An important source of earnings differentials among people who have completed the same level of education is age or amount of time already spent in employment. The discounting of earnings differentials among "typical" earnings profiles for the purpose of estimating the profitability of schooling assumes, in effect, that human capital investments cease with the termination of schooling. This assumption is not valid theoretically or empirically. The profiles do not automatically follow a particular level of schooling. Their shapes differ among people even at the same level of schooling and they are subject to explanation by the same human capital framework in which investments continue in the labor market after completion of schooling. Indeed, the major reorientation that human capital analysis has provided for labor economists is the shift of focus from analysis of

current earnings of groups to complete lifetime earnings profiles.

The analysis of the earnings profile is the starting point of the human capital study of earnings. According to this approach, earnings at any time are seen as a return on the skill level—the human capital stock embodied in the person and accumulated by him up to this time. Since the size of this capital stock grows over the life cycle by means of investment and declines because of depreciation and obsolescence, earnings change correspondingly. Specifically, the average level of the earnings profile depends on total investments (plus endowment), the slope (rate of growth) depends on investment prior to the observed period, and the rate of change (deceleration) in growth reflects the rate of decline of investments over the life cycle.

An average age profile of earnings shows rapid growth during the first decade of working life, lesser growth subsequently, and a leveling in the third and fourth decades. Such profiles are descriptive of earnings of homogeneous groups (for example, male workers with a fixed level of education), net of general economic fluctuations and trends over time. Approximations to such profiles are observable in cross-section data, which show earnings of persons of given education levels who differ in age.

In longitudinal data that have recently become available, we can observe individual earnings histories. The average longitudinal profile in a homogeneous group is affected by trends and cycles in the economy, but to the extent that those can be isolated, it bears a general similarity to the synthetic cross-sectional construct.

Why do earnings grow over the life-cycle in a decelerating fashion? According to human capital theory, the life-cycle growth of earnings reflects the rate of accumulation of personal investments (this is why economy-wide and random changes should be excluded). This self-investment can be analyzed as an optimizing decision of the individual.¹ Briefly, rational allocation requires that much of the investments in the person be concentrated at younger ages. The investments may increase initially, but continue at a diminishing rate through the rest of the working life. If it pays to invest early, why don't people undertake all their planned investments at an early age? The basic answer is that the cost of producing a unit of human capital is greater the shorter the time period of its production. The solution is to stagger investments over time and to decrease each dose in the time sequence. Investments diminish over time because, first, benefits decline as the payoff period (remaining working life) shortens and, second, the opportunity cost of time, which is an input in the learning

¹ This approach was pioneered by Becker (1967) and Ben-Porath (1967).

process, is likely to rise over the working life. While gross investment proceeds at a slackening rate throughout working life, net investments (gross minus depreciation) vanish or turn negative earlier. This occurs when depreciation (including obsolescence) begins to outstrip maintenance, a progression which eventually brings about retirement.

An alternative interpretation of the earnings profile is that it is an intrinsic age phenomenon; initial productivity growth corresponds to inherent biological and psychological maturation, while later stability and decline are due to first stable then declining physical and intellectual vigor. In the perspective of human capital this view is incomplete since it explains the earnings profile solely by a life-cycle pattern of the depreciation rate, seen as negative in early years, zero in middle life, and positive in later years. There is evidence, moreover, that indicates that this inherent age-depreciation factor affects earnings only to a minor degree, except at teenage and in the near or post-retirement years. In data in which age and length of work experience are statistically separable, levels and shapes of earnings curves are mainly a function of experience rather than of age. In addition, earnings profiles differ by occupation, sex, and other characteristics in systematic ways that cannot be attributable to aging.

One may also interpret the shape of the earnings profile as a "learning curve," or a reflection of growth of skills with age and experience known as "learning by doing." This view is not at all inconsistent with the human capital investment interpretation, as long as opportunities for learning are not costless. If more learning, and hence a more steeply rising wage, is available in some jobs compared with others, all qualified workers would gravitate to such jobs if learning were thought to be costless. In consequence, entry wage levels in such jobs would be reduced relative to entry wages elsewhere for workers of the same quality, thereby creating opportunity investment costs in moving to such jobs. Thus, it is not merely training on the job (formal or informal), but also the processes of occupational choice that give rise to investments beyond schooling. Similarly, geographic mobility and other labor turnover in search of higher real earnings represent investments in human capital. Job mobility of this sort declines over the working life for the same reasons that the training investments do, and reinforces the general concave shape of the earnings profile while imposing occasional discrete jumps corresponding to job turnover. It is not surprising, therefore, to find that individual longitudinal earnings profiles appear rather unstable, while they are considerably smoother and characteristically shaped when earnings of homogeneous groups are averaged.

EARNINGS FUNCTIONS²

The earnings function is a mathematical and econometric specification of the earnings profile. A simple recursion produces the basic accounting equation of the earnings function: Let "earnings capacity" in the time period t be the amount of earnings E_t (in dollars) that could be observed if there were no investments in t . Given investments C_t , however, observed earnings

$$(1) \quad Y_t = E_t - C_t.$$

Earning capacity grows over time as a result of investment: At time t earning capacity E_t exceeds E_{t-1} by the return on investments incurred in $(t-1)$. Thus,

$$(2) \quad E_t = E_{t-1} + r_{t-1}C_{t-1}$$

where r_{t-1} is the rate of return on the investments in $(t-1)$. By recursion:

$$(3) \quad E_t = E_0 + \sum_{j=0}^{t-1} r_j C_j,$$

so that

$$(4) \quad Y_t = E_0 + \sum_{j=0}^{t-1} r_j C_j - C_t.$$

In principle, the rates of return r may differ among periods, forms of investment, and persons. We do, however, suppress the subscripts whenever convenient. E_0 is "original" earnings capacity: If it originates at age 0 we can view it as a return on the person's genetic endowment and state of health at birth. If the starting point is after completion of schooling at entry to the labor force, E_0 is a mixture of genetic and environmental influences, the latter including parental investments of time, money, and effort, as well as schooling investments.

Data on the individual installments of investment are not easily observable, except for formal schooling and training programs, which are only a part of the story. Even so, it is years of school attainment

² This section is based on Mincer (1970, 1974).

and not dollar costs for which data are abundant. For this reason alone, it is preferable to express the right-hand variables in the earnings function in terms of "time spent in investment" rather than in dollar magnitudes. This is accomplished by viewing the ratio of investment expenditure to gross earnings as a time-equivalent amount of investment:

Define

$$(5) \quad k_t = \frac{C_t}{E_t}.$$

If t is a given year and $k_t = 20\%$, this means that 20% of the year's gross earnings was spent in investment. If the costs of investments are exclusively time costs, i.e., earnings forgone, then k does in fact represent the fraction of the year spent in investment activities.

Substituting Equation 4 in Equation 2, we have

$$(6) \quad E_t = E_{t-1}(1 + rk_{t-1}),$$

and by recursion

$$E_t = E_0(1 + rk_0)(1 + rk_1) \cdots (1 + rk_{t-1}).$$

With rk a relatively small number, a logarithmic approximation is appropriate, and

$$(7) \quad \ln E_t = \ln E_0 + r \sum_{j=0}^{t-1} k_j.$$

Some investments are in the form of schooling; others take the form of preschool care, job training, job mobility, medical care, acquisition of information, and so forth. At this stage of development of the earnings functions, the k -terms have been segregated into two categories, namely, schooling and postschool investments.

Thus Equation 7 can be written:

$$(8) \quad \ln E_t = \ln E_0 + r_s \sum_{i=0}^{s-1} k_i + r_p \sum_{j=0}^{t-1} k_j$$

where i runs over years of schooling and j over years of postschool experience. The investment ratios are represented by k_i during the school period and by k_j thereafter. The subscripts at r_s and r_p indicate

that, in principle, the rates of return on schooling may differ from the rates of return on postschool investment.

Equations 1 and 8 are specified in terms of net investment ratios (k). Net investments can be decomposed into gross investment and depreciation as follows: Let C_{t-1}^* be the dollar amount of gross investment in period $t-1$, δ_{t-1} the depreciation rate of the stock of human capital, hence of earnings E_{t-1} during that period, and $k_t^* = C_t^*/E_t$ the gross investment ratio. Then

$$E_t = E_{t-1} + rC_{t-1}^* - \delta_{t-1}E_{t-1}$$

and

$$\frac{E_t}{E_{t-1}} = 1 + rk_{t-1}^* - \delta_{t-1} = 1 + rk_{t-1},$$

by Equation 7. Therefore, $rk_t = rk_t^* - \delta_t$, and the function of Equation 8 can be written:

$$(9) \quad \ln E_t = \ln E_0 + \sum_{i=0}^{t-1} (r_i k_i^* - \delta_i) + \sum_{j=0}^{t-1} (r_j k_j^* - \delta_j).$$

The earnings function of Equation 8 or 9 must be adapted for empirical purposes in at least two respects.

First, the dependent variable E_t , "earnings capacity," is the earnings figure that would be observed if the individual stopped investing in himself in period t . Continued investment means, however, that "net" earnings (Y_t) are smaller than E_t by the amount invested, C . For practical purposes, I equate observed earnings with "net earnings."³

Since $Y_t = E_t(1 - k_t)$, the earnings functions can be written:

$$(10) \quad \ln Y_t = \ln E_t + \ln(1 - k_t),$$

substituting the appropriate expressions from Equation 8 or 9 for $\ln E_t$.

Next, the investment ratios k_t or k_t^* have to be given empirical content. In the schooling stage, $k_t^* = C_t^*/E_t$, where C_t^* are forgone

³ Note that observed earnings, as they are usually reported in statistical accounts, would equal "net" earnings if C_t consisted only of opportunity costs. Since direct expenditures are not usually "netted out," observed earnings overstate net earnings somewhat. Given the importance of opportunity costs in human capital investments, observed earnings more closely approximate the "net" than the "gross" concept.

earnings (E_t), plus tuition and cost-of-living differential attributable to schooling, minus student earnings and student aid. Without knowing the C_t^* for each individual, we know that k_t^* is not far from unity during school years, and this is a convenient approximation.⁴ In the post-school stage, we have only the theoretical hypothesis that k_t declines after completion of schooling, when it was close to unity. Positive earnings upon entry into the labor force mean that $k_t^* < 1$, and since C_t^* eventually declines to zero, so must k_t^* . Note that a monotonic decline of k_t^* is not inconsistent with an initial constancy or even increase in C_t^* . This means that concavity of logarithmic earnings profiles is not inconsistent with initial linearity or even convexity of dollar earnings profiles.

My own experiments with specifying k or k^* as functions of time proved that the simplest linear specifications fit as well as other forms. Recalling that $k_t^* = 1$ and putting $k_t^* = k_0^* - (k_0^*/T^*)t$, when T^* is the length of working life, we get:

$$(11) \quad \ln Y_t = \ln E_0 + (r_s - \delta_s)s + (r_p k_0^* - \delta_p)t \\ - \frac{r_p k_0^*}{2T^*} t^2 + \ln(1 - k_t^*).$$

Alternatively, in terms of net investment:

$$(12) \quad \ln Y_t = \ln E_0 + r_s s + r_p k_0 t - \frac{r_p k_0}{2T} t^2 + \ln(1 - k_t).$$

Here T is the period of positive net investment, so that $T < T^*$. Thus the peak of earning capacity when depreciation nullifies or outstrips gross investment is reached sometime before the end of working life.

For the purposes of econometric estimation, the term $\ln(1 - k_t)$ may be approximated by one or more terms. With a one-term approximation and a linearly declining profile of investment ratios, Equation 12 becomes:

$$(12a) \quad \ln Y_t = (\ln E_0 - k_0) + r_s s + \left(r_p k_0 + \frac{k_0}{T}\right)t - \frac{r_p k_0}{2T} t^2.$$

The timing of the peak of observed earnings, obtained from $(d \ln Y_t)/dt = 0$ is $t_p = T + (1/r_p)$. Therefore, $T < t_p < T^*$: Observed

⁴ It appears from 1960 U.S. data on college students that, on the average, student earnings plus scholarship roughly paid for tuition. Even if true on the average, this assumption is worth relaxing when data are available, as has been done in the recent work by Solmon (1973), Wachtel (1973), Johnson and Stafford (1973), and Leibowitz

earnings reach a peak sometime (perhaps a decade) after net investment has declined to zero but before gross investment ceases.

Hours of work appear to decline in the last decade of working life, according to available data. If capacity rather than observed wage rates is important in labor supply behavior, hours would decline before the peaking of wage rates is observed, while the end of working life (retirement) is likely to be linked to the cessation of gross investment (T^*).

Equation 12 permits a separate estimate of effect of schooling r_s , but r_p and k_o cannot be separately estimated. Estimates of the post-school investment profile can be obtained if it is assumed that r_s and r_p are the same.

We have not, as yet, distinguished between earnings and wage rates. Information on hours of work during the year permits this distinction. More interestingly, when such information exists for prior years, as in recently available longitudinal data, it is possible to separate the estimates of the postschool investment profile given by k_o and T from the rate of return, r_p , on these investments.³

As was noted, the investment ratio k_t is equivalent to the fraction of time at work devoted to investment in further progress of the worker. If all persons worked the same number of hours during the year and over the years, Equation 10 would estimate both annual earnings and wage rates. Otherwise, a fixed ratio k_t across individuals implies that people who work less invest correspondingly less. This is a plausible assumption within the theory, suggesting that opportunities as well as incentives to learn on the job are directly related to the amount of time spent at work. If people differ systematically in average annual hours they devote to the labor market, then an earnings function for wage rates must be distinguished from annual earnings equations. The derivation is as follows.

Let λ be the ratio of actual (annual) hours worked by person i to standard hours (say, 2,000 per year—the base is arbitrary), and let E_i^f be the full-time earning capacity and Y_i^f be observed full-time earnings (a fixed multiple of the wage rate per hour). Then

$$(13) \quad C_i = k_i E_i = \lambda_i k_i E_i^f,$$

(1974). The correction for quality requires relaxing the assumption that $k_i = 1$ during school years. This requires expenditure data that differ among schools for the numerator of k_i . Of course, expenditure data do not fully capture quality, particularly in the public school system. Still, accounting for variation in expenditures among schools was significant in the empirical analyses in the references cited above. See the section on school quality, below.

³ The procedure derives from an idea suggested by E. A. Hanushek and J. M. Quigley (1976).

so that

$$(14) \quad E_t^f = E_{t-1}^f (1 + r \lambda k_t).$$

Recursion of Equation 14 leads to:

$$(15) \quad \ln E_t^f = \ln E_0^f + \sum_{j=0}^{t-1} r_j \lambda k_j.$$

After the summation (integration in the continuous case) and substitution of $Y_t^f = E_t^f (1 - k_t)$,

$$\ln Y_t^f = \ln E_0^f + r_s s + r k_0 (\lambda t) - \frac{1}{2} r \frac{k_o}{T} (\lambda t^2) + \ln(1 - k_t).$$

With a linear approximation for the last term on the right:

$$(16) \quad \ln Y_t^f = \ln Y_0^f + r_s s + r k_0 (\lambda t) - \frac{1}{2} r \frac{k_o}{T} (\lambda t^2) + \frac{k_o}{T} t_i.$$

This is an equation for full-time earnings or wage rates. Since annual earnings are a product of wage rates and hours, the annual earnings equation (in logarithms) contains an additional term, $\ln \lambda_t$. Here λ_t refers to the current period t , while in the wage rate equation, λ is an average over the past excluding the current period t .

$$(17) \quad \ln Y_t = \ln Y_0^f + r_s s_t + r_p k_o (\lambda_t t_i) - \frac{1}{2} r_p \frac{k_o}{T} (\lambda_t t^2) + \frac{k_o}{T} t_i + \ln \lambda_t.$$

Since individual differences in levels of schooling s , work time λ , and elapsed years of working life t are observable, Equations 16 and 17 can be statistically estimated in the cross-section (with historical information on λ). In contrast to Equations 11 and 12, all parameters can be estimated: These are averages of rates of return to schooling (r_s), to postschool investment (r_p), linear investment profiles $k_t = k_o - (k_o/T)t$, and the net investment period T .

There are several merits in using earnings functions of types 12 and 16 relative to the calculations of costs and returns to schooling as differentials between earnings profiles of two schooling groups:

1. The earnings function permits an estimate of the effect of schooling on earnings (coefficient r_s) uncontaminated by and separately from estimates of effects and volumes (in dollars or time-equivalents) of postschool investments. The association between the schooling and postschooling investment is another relation that can be ascertained.

2. It sheds light on the role of age in the earnings profile: Age can represent a depreciation factor, but it is not a good measure of accumulated postschool investments. The latter are better indexed by actual experience in the labor market: Earnings rise rapidly during the early decade of work experience. At the same age, less educated workers are higher on their experience profile than the more educated workers are on theirs. Consequently, the differentials in earnings, that is, returns to schooling, in samples of young workers may be severely underestimated, and this is more generally true when age rather than experience is the variable used (as in most ad hoc analyses) in the earnings function. Age is an especially poor substitute for experience in the analysis of earnings of women, whose labor-market experience is often discontinuous. The earnings function, however, can be adapted to discontinuous work histories as well (cf. Mincer & Polachek, 1974).

SOME EMPIRICAL FINDINGS OF RESEARCH WITH EARNINGS FUNCTIONS

Earnings of Men

Multiple regressions of the functional form of Equation 12 run on large samples of the Decennial U.S. Census, as well as on other sample data, provide the following estimates:

1. The average rate of return to *schooling* varies between 7% and 11% in various bodies of data. It showed no time trend between 1949 and 1969, but there was a significant (about 1/3) drop in the rate between 1939 and 1949. Some indication of decline appears in the 1970s, based on fragmentary data (Freeman, 1976). The rate itself is higher at lower levels of schooling in the analysis of annual earnings but does not differ much by level of schooling in wage-rate comparisons.

2. The rate of return to *postschool* investments (r_p) and the average magnitudes of those investments are estimable by the regression form of Equation 14. Estimated from the *Michigan Income Dynamics* data (Hanushek & Quigley, 1976), r_p was about 13% at each education level, while the intercept of the investment profile was about 25% on

the average—lower (17%) at elementary-school levels and higher (32%) at college and beyond. With the net investment period T estimated at about 20 years and an assumed linear decline in the investment ratio, it would appear that men spend an equivalent of three years at work in activities promoting their advancement. In terms of opportunity cost, however, these job investments are not much less than the costs of schooling, since forgone earnings are much smaller at school ages.

3. The two variables, schooling and work experience, account for a third of the variance in wage rates. This is a significant insight into the structure of earnings, especially when it is realized that individual differences such as the quality of schooling, the differential rates of skill accumulation on the job or through job mobility, and "home investments" of parents in children are not captured by these few crude variables. Annual earnings is a product of wage rates and hours per year. When hours worked (or even only weeks worked) during the particular year are taken into account, the equation consisting of these easily available variables explained as much as half of the variation in earnings among men in the 1960 Census.

It is true, of course, that schooling and years of work experience are rather obvious determinants of wage rates and that (current) hours of work are an arithmetical factor in annual earnings. Their inclusion in earnings equations does not require analytical models such as human capital theory. The model, however, does provide guidance for the specification of these variables and of the equation form in ways that provide interesting interpretations. Some of the contributions of the human capital model to the analyses of earnings, as distinguished from ad hoc analyses with the same variables, are the following.

1. The coefficients of the function represent estimates of (average) rates of return and of volumes of investment in schooling and after schooling. It appears that rates of return are somewhat higher in postschool activities and that the total volume of investment is somewhat larger in schooling. Since the calculations are based on monetary values, one reason why the rate on schooling investments is less than that on job training is that schools are more likely to produce nonpecuniary returns, that is, "consumption" or cultural gains, in addition to monetary gains.

2. The relation between schooling and postschool investment can be observed and interpreted. In dollar terms, the relation is positive: More educated people invest more in the labor market. One interpretation is that the ability and opportunity factors that induce individu-

als to have more schooling also affect their postschool investment behavior. The correlation is far from strict: Abilities and opportunities change over the life cycle and there is a fair amount of substitution between the two forms of skill accumulation. Another interpretation of the same phenomenon is that schooling improves the efficiency with which people can absorb learning on the job, thereby leading to greater job investments. This hypothesis has not been tested on an individual level, but it is consistent, in a dynamic context, with evidence on the "worker allocative effect" propounded by Schultz (1975) and Welch (1970). Their proposition that education promotes the adjustment to technological change has been documented, mainly in studies of agricultural production activities.

3. The simple correlation between schooling and earnings is quite weak. In the Census data, previously referred to, the simple coefficient of determination between earnings and years of schooling for the whole sample was merely 7%. Even multiple coefficients of determination, after a number of other variables are added, remain relatively small, as in Jencks (1972). Standardizing for effects of age doubles the coefficient in age groups 35-44, but the coefficients decline below and above these ages.

The proper standardization suggested by the human capital framework is not by age but by experience. The R^2 by years of experience is a much more substantial 30% during the first decade of working life, with a gradual decay thereafter. The decay is due to the fact that, although positively correlated, postschool investments are not perfectly correlated with schooling investments at the individual level. The decay in the correlation does not set in until the second decade of work experience, because schooling differentials in earnings during the initial years of experience are attenuated by the greater incidence of postschool investment at higher levels of schooling. The experience structure of the education-earnings relation which the human capital theory makes intelligible is confounded in age classifications that tend to produce downward biases in studies restricted to limited age groups (see the review by M. J. Bowman, 1976).

Employment Effects

The more educated and experienced workers enjoy larger annual earnings than their less skilled fellows for two reasons: Their wage rates per hour are higher and the amount of time they spend in gainful employment during the year is greater. The relative importance of employment compared with wage rates is greater at lower

levels of schooling and at older ages. At lower levels of schooling the effects of education and of job experience are about equally divided between gains in wage rates and gains in employment stability. In contrast, the effects of higher levels of education are due largely to gains in pay rates.

The relation between human capital accumulation and employment is mutual in the postschool stage. The more stable the employment and the more time spent at work, the greater both the opportunities and the incentives for further job investments. Conversely, the greater the earning power (in part due to past investments in human capital), the greater the payoff from additional work. This last statement must be qualified, however, by the opposite effects of resultant increases in income or wealth which are likely to increase the demand for consumption time or leisure. It can be shown, however, that so long as the rate of return on schooling investments is not exorbitant, human capital investments increase wealth less than they increase wage rates. Positive effects of wage rates on time at work are therefore likely to dominate in a cross-section of workers differing in education.

Induced labor-supply behavior may explain in part why hours of work and labor-force participation increase with education. Other factors that help to account for the observed positive correlation between education and employment are health differentials and differences on the demand side:

1. There is some evidence that physical capital is more easily substitutable for unskilled than for skilled labor. If fluctuations in output are produced with relatively fixed physical capital, the employment of unskilled labor must fluctuate more than that of skilled labor.

2. Employers invest resources in the training and experience of their employees to the extent that the resulting increases in worker productivity are more effective in their firms than elsewhere. To guard against capital losses in such investments, firms tend to minimize layoffs of their "specifically" trained workers. Insofar as these "specific" job investments are related to educational attainments of workers, they are a factor in the unemployment differentials observed by education. As mentioned before, worker self-investments appear to increase with levels of schooling. Employers, in turn, tend to invest more in the more educated workers, either because job specificity is more likely in more complex jobs or because they think education confers greater capacity and motivation for training.

3. A variety of institutional factors may account for differences in unemployment and labor force participation among educational

groups. Minimum wages on the demand side and income maintenance programs on the supply side tend to price low-quality labor out of the market. Consequently, inexperienced and uneducated workers with submarginal market productivities are frequently unemployed or withdraw from the labor market into welfare.

Earnings and Employment of Women

In the United States the educational attainment of women is not very different from the attainment of men, except for still sizable differences in higher and professional education. Wages of women are, on the average, 30–40% lower than wages of men and the differences are even larger on an annual basis. The comparison of sex differentials in earnings provides a major illustration of the difficulty of understanding the effects of education when other investments in human capital are disregarded.

Even today, after a long and upward trend in the market employment of women, their average labor force rate is about 50%. This, of course, does not mean that one-half of all women work all the time and the other half never works. Rather, it represents a spectrum of full-time and life-long work behavior of some and intermittent or part-time participation of others. According to Census (NLS) data, less than 50% of married women worked in 1966, but close to 90% worked sometime since they left school. More than half of the working women dropped out of the labor force when the first child was born and large numbers returned after the youngest child reached school age. In contrast, women without husbands and without children spent close to 90% of their working lives in the labor market.

The lesser amount and often discontinuous pattern of women's market work reduce both their incentives and opportunities, as well as the incentives of employers to invest in furthering women's skills in the market place. Consequently, the growth of wages with age is much smaller for women. Even if wages of women grew at the same rate as wages of men in intervals of work activity, the overall growth would be half as large for women since they work, on the average, half the time. However, expectations of discontinuity (or uncertainty about it) reduce investment incentives even further while the actual periods of withdrawal from market work tend to erode acquired skills. Thus, average wage growth in women's earnings profiles is less than half the wage growth of men. Note that the widely held view of wage discrimination against women refers to differences in wage *levels*, while the human capital hypothesis implies differences in wage *growth* resulting from differences in work experience. In principle, the two hypotheses

are not mutually exclusive, but the literature on sex differentials in wages contains as yet little or no attempt to identify distinct implications of each of these hypotheses.

The empirical analysis of data containing earnings and work and family histories of women is consistent with human capital hypotheses. We observe that although starting wages of men and women (with the same educational qualifications) do not differ much, they grow apart over the subsequent decades. However, the profiles of women who work continuously are much closer to those of men.

An adaptation of the earnings function to deal with discontinuous work experience has made it possible (Mincer & Polachek, 1974) to decompose the human capital factors involved. Rates of return to school education do not appear to differ between the sexes. Lesser work participation implies both a lesser payoff and lesser costs (forgone earnings). Close to half of the differences in wages emerging two decades following school were due to shorter accumulated work experience and to depreciation resulting from long gaps (usually when children were small) in participation. The estimated depreciation rate increased with level of schooling. This phenomenon counteracts the higher labor force rate of more educated women in the combined effects on wage rates.

The fact that labor force rates of women increase with education is of special interest. Though similar in direction to the behavior of men, education-associated differences in employment are much stronger among women than among men. The higher market earning power of the more educated women induces families to substitute, to some extent, purchasable goods or services for their work in the household. This kind of substitution is stronger than the substitution between market work and leisure which are still the more typical alternatives for men. Indeed, the strong substitution response to the growing wages (and education) in women's allocation of time between market and home is the basic factor in the historical growth of the female labor force (Mincer, 1962).

Although more educated women generally spend more time in the labor market, they are more likely to reduce their market work to take care of their children, particularly when they are of preschool age. The opportunity cost of shifting from market to home as measured by the forgone market earnings is much greater for the more educated women. Maternal withdrawal from the labor market represents one component of the parental investments in the human capital of their children. It may contribute to the explanation of the importance of family background in children's school performance and of the positive correlation between the educational attainment of children and of

their parents, particularly the mother. Whether such preschool investments have an effect on the children's earnings, beyond affecting their education, is a question that is answered negatively in much of the current research, but it is far from settled. In any case, the greater earnings—and presumably also the consumption capacities of children—may be viewed in the family context as a part of the return on the education of mothers. If so, the profitability of educating women is understated when inferred from their earnings alone.

An important consequence of the higher opportunity cost per unit of time spent in child care by more educated mothers is the reduction of total time so spent. This is accomplished largely by a reduction in the number of children. The strong inverse relation between education of mother and number of children is repeatedly documented. Taken together, it appears that growth of wages and of education is, in part at least, responsible for the major social trends of our time, such as the growing market employment of women (with all that this implies for the family), declines in fertility, and increases in human capital investments (especially education) in the resultant smaller number of children per family.

HUMAN CAPITAL AND THE INCOME DISTRIBUTION

Shape of the Distribution

There are several prominent features of the statistical distribution of earnings that are repeatedly observed in temporally and regionally differing data. Aggregate skewness and the growth of inequality with age are the best known. Other features are less familiar, and perhaps less stable. These characteristic patterns have puzzled observers ever since statistical data have become available. Largely noneconomic hypotheses ranging from genetic configurations to chance ("random shock") income fluctuations have been proposed to explain the shapes of income distributions.

In the human capital framework, most of these features can be explained by the correlation between the stock of human capital at any stage of the life cycle and the volume of subsequent investment. This correlation is understandable if incentives and opportunities for self-investment tend to persist over long periods of life. One example of this correlation, mentioned before, is the steeper growth of earnings with experience at higher levels of schooling. The statistical consequence is that earnings profiles "fan out"; hence, variances of earnings increase with experience and with age. Similarly, because the dispersion of schooling costs increases with the level of schooling,

variances of earnings increase with levels of schooling. The resulting positive correlation between means and variances in age and schooling subgroups of the earnings distribution is a sufficient condition for the appearance of positive skewness in the aggregate.

This factor is independent of (and, in a way, more basic than) the shape of the distribution of schooling which may itself contribute to positive skewness in earnings. Since the earnings function relates years of schooling linearly to logarithms of earnings, even a symmetric distribution of years of schooling must result in a positively skewed distribution of earnings. When the overall level of schooling is less, the distribution of years of schooling tends to be positively skewed. It becomes symmetric as average attainment rises. In the United States, skewness in the distribution of schooling has turned negative in the younger cohorts. So the shape of the distribution of schooling (measured by years) is no longer an important factor in explaining the persistence of positive skewness in the distribution of earnings in the U.S. As the level of schooling in the U.S. is among the highest anywhere, the findings of aggregate skewness in earnings in most other countries is not surprising.

Education and Income Inequality

According to the earnings function of Equation 12, the relative (logarithmic) variance of earnings is a positive function of the variance in years of schooling in year-equivalents of other investments, of the size and variance of the rates of return, and of the covariances between rates and volumes of investment. Using these parameters as well as variances in the distribution of employment, Chiswick (1974) was able to explain over 85% of the interregional differences in relative earnings inequality.

Using the same approach, Chiswick and Mincer (1972) studied annual changes in inequality among U.S. males (ages 25-64) between 1939 and 1969. Again, over 85% of the annual variation was explained by these parameters, even though no long-term trend was observed after 1949. There was a strong decline in inequality between 1939 and 1949 which was attributable in part to the decline in unemployment and in part to a sizable reduction (about one-third) in the rate of return to education.

Many observers are puzzled by findings that the inequality of earnings has not narrowed in the postwar era despite the large increases in mean education levels and despite the narrowing of educational disparities in years of schooling during this period. A sensitivity analysis (Chiswick & Mincer, 1972) of the estimated parameters of the earnings functions suggests that even large changes (in standard deviation units) in the distribution of schooling and of age have minor

effects on annual earnings inequality. The strongest effects are produced by changes in rates of return. Indeed, economic theory predicts that increases in educational investments should lower the rate of return on the investment and narrow the income differentials. This did not happen. A reasonable hypothesis, not fully documented, is that the supply of educated labor grew largely in response to growing demands, leaving rates of return roughly stable. Prior to the Second World War, low family incomes hampered investments in education and inhibited such supply responses. Consequently, the rate of return was and remained (too) high, until the postwar affluence and subsidies to education spurred a boom in enrollments.

SCHOOL QUALITY

The measurement of school education by the number of years spent at school is excessively crude for much the same reason that the measurement of work experience ("postschool investments") merely by elapsed years of working age is. The problem of measuring school quality has been attacked in several ways: by using school expenditures per student, salaries or other characteristics of teachers, and various ratings of schools as indicators of quality. Inclusion of such data in the earnings function reveals positive effects on earnings of greater resources per student, superior teachers, or higher ratings of schools. Johnson and Stafford (1973) find that a 10% increase in school expenditures per student increases the annual return to schooling by close to 2%; Wachtel (1974) found similarly strong effects in data in which student test scores were available as well; the correlation between school quality measures and student test scores was also quite high. Wise (1975) also found strong effects of school quality on earnings and even on rates of advancement of workers in a large firm.

Since better students and better schools tend to select one another, a clear analytical separation of student ability from school quality cannot be achieved in aggregated data such as school districts, counties, or states (Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld, & York, 1966; Johnson & Stafford, 1973). Micro-data, based on individual students, do show the separate effects more convincingly (cf. Wachtel, 1974, 1975; Solmon, 1973; Taubman, 1976a, 1976b; Hauser & Sewell, 1975).

ABILITY, OPPORTUNITY, AND INCOME

The main subject of the initial work in human capital has been an elucidation of costs and returns to education and other investments in

human capital including the estimates of private and social rates of return to such investments. Subsequently, human capital theory has been widely applied to the study of the structure of earnings, by schooling, labor market experience, occupation, sex, region, and so forth. In this analysis the distribution of earnings is viewed as a direct reflection of the distribution of accumulated stocks of human capital among members of the labor force. The appropriate qualifications, if the reader needs to be reminded, are that this statement refers, first, to real wages, so that nonpecuniary aspects of work may be reflected in compensatory money wage differences and, second, to equilibrium tendencies, since in the short-run wages may deviate from the norm because demand has changed and supply has not yet adjusted.

Granted that the distribution of human capital among persons affects the distribution of their earnings, what are the reasons for differences among persons in the distribution of human capital? This is an interesting and important question. In terms of economic analysis generally applied to investment behavior, the volume of individual investments in human capital is determined on the demand side by the productivity of such investments and on the supply side by their cost. The equilibrium amount of investment is attained when an additional unit of investment, say, an additional year of schooling, brings about an expected increase in real income that is just equal to the increase in cost.⁶ From the individual's point of view, this is the best he can do, given his abilities and his financial circumstances.

In principle, such constrained optima exist either because of diminishing returns on the demand side, where additional gains in income diminish as investment increases, or because of a rising supply price, i.e., the marginal costs of the investment rise as more is invested. Although the volume of accumulated human capital, together with the (marginal) rate of return on it, determines income, all three are simultaneously determined by the more fundamental forces of demand for and supply of human capital. In substantive terms, individual demand for human capital depends on the efficiency with which the person can put it to use, while individual supply depends on the terms of financing the costs of such investment. Thus, personal ability and investment financing opportunity are the ultimate determinants of earnings, but the proximate cause or instrumentality by which earnings capacity is achieved is the accumulated human capital.

If equality of opportunity (defined by equal terms of access to capital funds) prevailed, income differentials would still exist because more able persons would have incentives to invest more. Conversely,

⁶ This approach is spelled out in Becker (1967).

even if all people were (potentially) equally able, differential opportunities, due either to differences in inherited wealth or to other constraints, would result in differences in investments and therefore in earnings.

Given upward sloping supply curves and downward sloping demand curves, equality of opportunity (a common supply curve) implies a positive correlation between volumes of individual investments and (marginal) rates of return, while equal efficiency or ability implies a negative correlation. In U.S. data, the correlation between educational attainment and rates of return is negative and close to zero, suggesting that inequality of opportunity is at least as important as the inequality of abilities in creating the existing inequality in earnings (Mincer, 1970).

A great deal of research by economists and sociologists is devoted currently to the elucidation of the role of ability and opportunity in earnings. These factors may influence earnings directly or indirectly via schooling and other human capital acquisitions. Repeated observations of a positive correlation between educational attainment, socioeconomic background, and assorted measures of ability are not surprising in light of the economic analysis of human capital investment behavior. But they are also a basis for questioning the association between education and earnings. Is it not plausible that more educated people could earn more because of their ability and background in any case, rather than as a result of the schooling process? In less extreme form the question is, how biased are the estimates of the effects of education on earnings by the omission of the ability and family background variables?

In the human capital approach, ability plays a double role: as the initial endowment that exists prior to investments but also as an interactive factor or efficiency parameter because more able persons receive a higher rate of return on the same investment. Denison (1962) conjectured that ability accounts for about 40% of the effects of education on earnings. Becker (1975) argued that the opportunity costs of college graduates are understated when measured by typical earnings of high school graduates, if the latter are less able than typical college graduates. The adjustment, using fragmentary evidence on IQ, was not sizable. Since that time much greater attention has been devoted to this adjustment problem in econometric studies. Most of them conclude that the true effect of schooling on earnings is major and the correction for ability bias is minor (Welch, 1974).

Aside from problems related to the variety of ability measures (from IQ to AFQT), there is the question of the age at which the measure was taken. As is well known, these measures grow over time

with age and with education. Griliches and Mason (1972) estimated that the coefficient of schooling is reduced by 7-10% if IQ measure prior to high school is included, while if IQ of adults is used the downward bias in the schooling coefficient is exaggerated by almost 100%.

Unless what is meant is racial discrimination, class collusion, or nepotism, it is more difficult to visualize the nature of the direct effect of opportunity or socioeconomic background on earnings.⁷ The indirect effects may run via genetic inheritance, which would be manifested in the ability traits already discussed, or in the quality of the early environment including purposive investment by parents in the early human capital stock of their children. Most of the studies that include family background variables in the earnings equations report small effects, net of human capital variables like schooling and experience. On the other hand, the background variables, which usually include parental occupation, education, and number of siblings, are shown to be significant predictors of the child's educational attainment. As an example, Corcoran, Jencks, and Olneck (1976) report a study of several large bodies of data in which they found strong family background effects on children's education and test scores, but no effects on their earnings, once education and test scores are controlled.

The Griliches-Mason work (1972) previously noted shows the importance of the indirect effect in another way. Their measure of schooling is partitioned into schooling completed prior to serving in the armed forces and subsequent schooling. By controlling for background variables, the early schooling coefficient is reduced by 25%, but the post-armed-service schooling effect shows a negligible reduction.

In a more recent study (1976) of young men, Griliches finds that parental background and region of origin account for about a quarter of the variance of measured IQ. Together with IQ they account for about a half of the variance of schooling. Later ability (at survey) is affected about equally by schooling and by early ability (IQ), as well as by parental background. Working through the recursive equations system, Griliches concludes that the relation between education and earnings is not spurious. There remains an important and sizable effect of schooling on wages, net of family background and of measured IQ. At the same time, the ultimate effect of background variables on earnings is quite attenuated. As an illustration, the estimated equations system implies that two young men who are one standard

⁷ Direct effects in consumption and on property income via gifts and bequests are, of course, observable.

deviation apart on each of the family variables and on IQ would find themselves about .75 and .4 of a standard deviation apart on schooling and wages, respectively. This is a rather strong regression toward the mean, with important implications for income mobility.

Other studies find lower coefficients of schooling and larger effects of ability and of family background. Some of these findings are, in part, biased by the use of age standardizations. In the Hauser-Sewell (1975) study, which covered no more than eight years of early work experience, the effects of schooling appeared to be negligible. In a recent extension of that study in which the panel was updated to 14 years, Hauser and Daymont (1976) replace age by experience in their equation and find in consequence that the schooling coefficient doubled in size (to 9-10%), while the ability-background bias was reduced to about 15% of the schooling coefficient. These findings approximate the results reported by Griliches and summarized for other studies by Welch (1974).

Perhaps the major problem with the background factors is the difficulty of measurement. IQ or other scores do not really measure the ability to earn, nor does father's occupation or other available family data fully capture the degree of financing or market opportunity. An indirect approach is to analyze earnings of siblings, presumably because the intrafamily variation is less affected by ability differences. Of course, intrafamily analyses reduce not only variations in ability but also in other advantages or disadvantages provided by the family background.

An example of this work is a variance component model of data for young men (Griliches & Chamberlain, 1975). Ability is viewed as an unobserved factor with a common family component. In this sample, exclusion of "ability" did not appear to bias estimated effects of schooling on earnings. Taubman (1976) carries the intrafamily approach to its logical extreme by analyzing earnings of identical and fraternal twins. A basic assumption in the analysis of twins is that identical twins differ from each other environmentally as much as fraternal twins do, while the variance in genotype is clearly much greater among fraternal twins. Consequently, the genetic effects can be isolated in statistical analyses involving both sets of twins. Taubman concludes that genetics could account for 20-40%, and common family environment for 8-15%, of the variance in earnings. Both account for about 70% of the variance in schooling, but differences in the schooling of twins have very small effects on their earnings.

Goldberger (1976) has expressed doubt about the statistical identification of parameters in the twin data: His analysis raises strong objections to the assumption of equal environmental correlation.

Griliches (1977), as well as Welch (1974), maintains a methodologically pessimistic view to the effect that measurement errors become increasingly mischievous as the models become increasingly complex, putting an insupportable burden on the data. The more refined the data or the more variables included in the analysis, the smaller the intragroup variance. The relative importance of the same measurement error in the smaller variance can become overwhelming.

A substantive comment on the intrafamily analyses emerges from the recent work of Becker and Tomes (1976). Granted that ability, motivation, and family background are much less variable among siblings than in the whole population, it is not the variation in such characteristics but the covariation with amounts invested in human capital that is the source of possible bias in estimates. For example, if parents tend to provide more education to the more able or motivated of their children, intrafamily effects may not be reduced relative to those across the whole population. Conversely, if similar education is provided to less and more able children, the within-family relation between education and earnings may well appear to be tenuous, especially in the presence of measurement error.

Imprecise measurement is not restricted to the determinants of earnings. Earnings themselves are not fully measured by paid-out money wages. The missing components are so-called fringe benefits, some of which are deferred payments such as pensions or contributions to medical insurance, while others are in the form of various perquisites or comfortable working conditions. The demand for deferred payments and fringe benefits is a positive function of income for two reasons. First is the usual income effect on consumption, and second is the effect of the increasing marginal tax rate as income rises. Indeed, calculations of the value of fringe benefits and of deferred payments show that these components of wages increase more than in proportion to the currently received wage. Consequently, omission of these "wage supplements" creates *downward* biases on the measured effects of human capital investments.

In a recent study of two national sample data sets in which information on wage supplements and fringe benefits was available, Duncan (1976) found that the schooling coefficient increased as much as 20% when the "nonwage" variables were added to the earnings measure. The increased return to education was sustained even when measures of ability, motivation, and family background were taken into account. Indeed, the upward correction of the schooling coefficient due to the omission of wage supplements and fringe benefits was at least as great as the alleged bias due to omission of

background variables in a single-equation education-earnings function.

I think it is fair to say, based on the preponderant evidence thus far, that employers pay for characteristics and efforts of the workers, not of their parents. The economic analysis of human capital investment decisions suggests that the effects of background variables are *indirect* by influencing the accumulation of human capital. Since the latter is commonly measured only crudely by years of schooling and by years of work experience, the relatively small direct (net) effects of background variables that remain might well disappear with the introduction of more refined measures of human capital.

SOME CRITIQUE AND RESPONSE

Accepting the reality of an education-income relationship, some critics question the interpretation that schools contribute anything to individual marketable (especially cognitive) skills. These critics do not believe that wage differentials shed any light on productivity differences. Actually, research on production functions by Griliches (1963, 1967) and others has shown that not only differences in wage rates but also differences in productivity are related to differences in the education of the labor force across states, regions, or enterprises. The potential contribution of education to aggregate economic growth is not merely a conjecture. But these findings tend to be ignored by critics.

Other critics claim that it is not cognitive knowledge but socialization that schools accomplish (Gintis, 1971). Still others assert that schools serve as a filter to sort differences in ability that exist independently of schooling—this is the so-called screening hypothesis. Although these views about the content of the contribution of education appear provocative, they do not conflict with the fundamental notion of human capital—of forgoing current income for increased future earnings. For this general concept, it does not matter whether the increased marketability produced by schools is due to their affective, informational, or cognitive function.

In principle, indeed, schools are institutions with all of these purposes, and the search for student talent by the school and by the student is an activity no less important than the search for any other scarce natural resource. It is true that the private return from the production and dissemination of information may exceed the social return. But the empirical magnitude of this differential is likely to be exaggerated.

The productivity and screening functions of schooling are not mutually exclusive in a world of imperfect information, given that ability is an input in the educational process. The controversy, if any, concerns the *relative* importance of the productivity and screening functions of schooling in affecting earnings. Unless screening is a deliberate device for monopolization, its effect on earnings can be neither major nor durable, once the productivity of the worker can be directly observed. Moreover, the characteristics for which schooling serves as a screen should be discoverable by means of direct interviewing and testing much more cheaply than by expenditures of many years and tens of thousands of dollars on an average education. Markets for testing would surely spring up if such tremendous savings were possible; their absence is a strong argument against a "pure" screening hypothesis.

Even the proponents of screening as the major function of schooling do not maintain that the screen is permanent. If it were, the correlation of schooling with earnings would be fixed at all levels of work experience. This is obviously false, as was already indicated. Individual correlations between schooling and earnings decay over time, while differential job turnover and advancement within jobs create huge variances in wage levels and wage progressions among individuals possessing identical "screens."

The validation of positive effects of education on income has led to careless claims about the marketability of schooling. If what is being done at school matters, it cannot be merely a question of how many years a student spends there, but how many years are spent. Let us also not forget that the estimated rates of return suggest a reasonable investment, even purely in market terms, only *on average*. The dispersion in the rate means that a sizable proportion of below-average students may do better with other investments, unless they are the ones who weigh the nonpecuniary benefits more heavily.

It also appears that the economics of education, or its misinterpretation, has led to exaggerated hopes for the achievement of egalitarianism. Superficially, it would seem that an expansion of schooling and reduction in the variance should reduce income inequality. Since World War II, education has been expanded and democratized throughout the Western world with rather small effects on income inequality. The expected effects did not materialize simply because an expansion in the supply of educated labor will not lead to a reduction in the rate of return, and hence a reduction in inequality, unless the demand for educated labor is increasing at a less than comparable rate. In view of the positive relation between rates of

return to education and rates of growth of economies or regions, as shown in the research of Schultz (1975) and Welch (1970), growth in the postwar period has been biased in favor of skills.

It appears that a slowdown in population and economic growth has reduced the demand for education in recent years. Whether the drop in demand for educated labor is a short-run or long-run phenomenon (cf. Freeman, 1976), I rather doubt that the social benefits of a reduced variance in income will outweigh the problems that even a transitory cohort of unemployed intelligentsia can create. I say transitory, because economic analysis assures us that supply adjusts to demand on the downswing as well as on the upswing, so a new, lower equilibrium is looming—witness the declining enrollments in response (in part) to the lessened profitability of education.

The expectation that education will reduce the cross-sectional variance in U.S. incomes is probably misplaced. Rather, the traditional egalitarian effects of education should be viewed in terms of social mobility. Both the proponents of education as a tool of egalitarianism and their radical critics appear to underestimate the degree of social mobility that did occur and the role of the schooling system as a source of social mobility (Blau & Duncan, 1967) for individuals and for successive waves of immigrant groups in U.S. history (Chiswick, 1976).

The economists' inquiries into market productivity and into the informational and distributional effects of education may hearten or discourage educators and policymakers. But they should not obscure the central role of education in society. Education is neither a panacea nor a conspiracy. It is and will remain the basic enterprise for the transmission and growth of human culture.

REFERENCES

- Becker, G. S. *Human capital and the personal distribution of income*. Ann Arbor: University of Michigan, 1967.
- Becker, G. S. *Human capital* (2nd ed.). New York: NBER, 1975.
- Becker, G. S., & Tomes, N. Child endowments and the quantity and quality of children. *Journal of Political Economy*, 1976, **84**(4), S143-S162.
- Ben-Porath, Y. The production of human capital and the life-cycle of earnings. *Journal of Political Economy*, 1967, **75**(4), 352-365.
- Blau, P. M., & Duncan, O. D. *The American occupational structure*. New York: Wiley, 1967.
- Bowman, M. J. Through education to earnings? *Proceedings of the National Academy of Education*, 1976, **3**, 221-292.

- Chamberlain, G., & Griliches, Z. Ability, schooling and the economic success of brothers. *International Economic Review*, 1975, 16(2), 422-450.
- Chiswick, B. R. *Income inequality*. New York: NBER, 1974.
- Chiswick, B. R. *The Americanization of earnings*. Unpublished manuscript, 1976.
- Chiswick, B. R., & Mincer, J. M. Time series in personal income inequality in the U.S. since 1939. *Journal of Political Economy*, 1972, 80(3), Part 2, S34-S66.
- Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. *Equality of educational opportunity*. Washington, D.C.: U.S. Department of Health, Education, and Welfare, Government Printing Office, 1966.
- Corcoran, M., Jencks, C., & Olneck, M. The effects of family background on earnings. *American Economic Review, Proceedings*, 1976, 66(2), 430-435.
- Denison, E. F. *Sources of economic growth in the U.S.* New York: Committee for Economic Development, 1962.
- Duncan, G. J. Earnings function and nonpecuniary benefits. *Journal of Human Resources*, 1976, 11(4), 462-483.
- Freeman, R. B. *The overeducated American*. New York: Academic Press, 1976.
- Gintis, H. Education, technology and productivity. *American Economic Review, Proceedings*, 1971, 61(2), 266-279.
- Goldberger, A. S. *Twin methods: A skeptical view*. Paper presented at the Conference of the Mathematical Social Science Board, May 1976.
- Griliches, Z. The sources of measured productivity growth. *Journal of Political Economy*, 1963, 71(4), 331-346.
- Griliches, Z. Production functions in manufacturing. In M. Brown (Ed.), *Theory and empirical analysis of production (Studies in Income and Wealth, Vol. 31)*. New York: Columbia University Press, NBER, 1967.
- Griliches, Z. Wages of very young men. *Journal of Political Economy*, 1976, 84(4), Part 2, S69-S86.
- Griliches, Z. Estimating the returns to schooling. *Econometrica*, 1977, 45(1), 1-22.
- Griliches, Z., & Mason, W. Education, income and ability. *Journal of Political Economy*, 1972, 80(3), Part 2, S74-S103.
- Hanoch, G. An economic analysis of earnings and schooling. *Journal of Human Resources*, 1967, 2(3), 310-329.
- Hansen, W. L. Total and private rates of return to investments in education. *Journal of Political Economy*, 1963, 71(1), 128-140.
- Hanushek, E., & Quigley, J. *Explicit tests of the human capital model* (Working Paper 767). New Haven, Conn.: Yale University, 1976.
- Hauser, R., & Daymont, T. *Schooling, ability and earnings* (CDE Working Paper 76-19). Madison: University of Wisconsin, 1976.
- Hauser, R. & Sewell, W. *Education, occupation and earnings*. New York: Academic Press, 1975.
- Jencks, C., et al. *Inequality*. New York: Basic Books, 1972.
- Johnson, G. E., & Stafford, F. Social returns to quantity and quality of schooling. *Journal of Human Resources*, 1973, 8(2), 139-155.
- Leibowitz, A. Home investments in children. *Journal of Political Economy*, 1974, 82(2), Part 2, S111-S131.

- Mincer, J. Labor force participation of married women. In *Aspects of labor economics*. Princeton: Princeton University Press, NBER, 1962.
- Mincer, J. The distribution of labor incomes: A survey. *Journal of Economic Literature*, 1970, **8**(1), 1-28.
- Mincer, J. *Schooling, experience and earnings*. New York: Columbia University Press, NBER, 1974.
- Mincer, J., & Polachek, S. Earnings of women. *Journal of Political Economy*, 1974, **82**(2), Part 2, S76-S108.
- Schultz, T. W. The value of the ability to deal with disequilibria. *Journal of Economic Literature*, 1975 **13**(3), 827-846.
- Solmon, L. Schooling and subsequent success. In L. Solmon & P. Taubman (Eds.), *Does college matter?* New York: Academic Press, 1973.
- Solmon, L., & Taubman, P. (Eds.). *Does college matter?* New York: Academic Press, 1973.
- Spence, M. *Market signalling*. Cambridge, Mass.: Harvard University Press, 1974.
- Taubman, P. *Sources of income inequality*. New York: North-Holland, 1976. (a)
- Taubman, P. The determinants of earnings: Genetic, family and other environments. *American Economic Review*, 1976, **66**, 858-870. (b)
- Wachtel, P. *The effect of school quality on achievement, attainment and earnings*. New York: New York University, 1974.
- Wachtel, P. The returns to investment in education: Another view. In F. T. Juster (Ed.), *Education, income, and human behavior*. New York: McGraw-Hill, 1975.
- Welch, F. Education in production. *Journal of Political Economy*, 1970, **78**(1), 35-59.
- Welch, F. Relationships between income and schooling. *Review of Research in Education*, 1974, **2**, 179-201.
- Wise, D. Academic achievement and job performance. *American Economic Review*, 1975, **65**(3), 350-366.

Chapter 2

EDUCATIONAL PRODUCTION FUNCTIONS

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AN EDUCATIONAL production function relates the levels of identifiable educational outcomes to the quantities of identifiable educational inputs. It is fundamentally a microeconomic concept, designed to apply at the level of an individual student. However, empirical estimation of educational production functions has been based on data aggregated to different degrees on both the output and the input sides as well as on individual student data.

The objective of this review of educational production functions is fourfold: first, to summarize the empirical experience in the estimation of educational production functions; second, to provide an exposition of the basic theoretical elements of educational production functions; third, to identify problems in empirical implementation; and, finally, to indicate potentially fruitful directions for further research. This review is not intended as a comprehensive survey of the literature on educational production functions, and the author apologizes for any inadvertent errors or omissions.

As a theoretical construct, the educational production function serves as a useful organizing device for the study of the educational sector. Empirical estimation of the educational production function, on the other hand, has been primarily motivated by a desire to evaluate the efficiency and optimality of the educational sector. However, empirical research to date is characterized by sufficient inconsis-

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tency and uncertainty that any evaluation based on it would be premature. This review is therefore not focused on evaluation or potential evaluation of the educational sector, but on the possibility of identification of the technological relationship between educational outputs and inputs.

Nevertheless, it should be noted that ultimately a knowledge of the technological relationship between educational outputs and inputs can be used to promote efficient allocation of resources within the educational sector. For example, given the educational production function and the prices of the educational inputs, one can determine the minimum cost combination(s) of the educational inputs that can produce a prespecified vector of educational outputs. If, in addition, the social valuations of the educational outputs are also specified, then one can perform a cost-benefit analysis on any change in the composition of educational outputs. Thus, the educational production function can play a substantial role in the comparison and evaluation of alternative educational policies.

EDUCATIONAL PRODUCTION, OUTPUTS, AND INPUTS

Special Features of Educational Production

Several technological and behavioral features distinguish the educational production process. From the technological point of view, educational production differs from a more conventional production in at least four respects. First, educational production is typically a multiple-outlet process. Second, time is an essential element in educational production. The period of production in education, as in agriculture, is basically incompressible. However, unlike agriculture, educational outputs are not point outputs but typically consist of a time profile of educational achievements or knowledge.¹ Moreover, not only do the cumulative quantities of inputs make a difference, but so also do the shapes of their time paths and their sequential arrangement relative to one another. Third, the raw material in educational production (the student), unlike other raw materials, is not completely passive. It reacts and responds to the actions of the educational producers. Finally, educational production is characterized by at least two types of externalities. The first is a public goods externality, which arises because some inputs, for example, teacher lecturing time, can contribute to the production of educational outputs in a

¹ Thus, education undertaken in the current period may have a residual value many periods hence.

whole class of students simultaneously. The quantity of teacher lecturing time received by each individual student is, within broad limits, unaffected by the total number of students. The second is a peer-group externality, which may be said to exist if an individual student's ability and will to learn depend on the ability and will to learn of his or her classmates, so that the cognitive achievement of an individual student is correlated with the cognitive achievements of the whole class.

From the behavioral point of view, there are two major differences. First, educational producers, unlike a more conventional producer, cannot be assumed to maximize profits or minimize costs or even to maximize utility. Second, control of quantities of inputs to the educational production process is not vested in a single manager. Instead, it is diffused among administrators, teachers, parents, and even students—a group that we shall refer to collectively as the actors of the educational production process. Each of these actors has some degree of control over the outputs and the inputs and tries to further his or her own objective, taking into account the actions of the others.² Individual actions are also heavily constrained by state educational laws and regulations. The outcome of the educational production process thus depends not only on the technology but also on the behavior of the individual actors in a complex way. In order to understand fully the behavior of the educational sector, one needs to study and model the behavior of the individual actors as well.

Educational Outputs

Educational outputs can be classified into two types: cognitive and noncognitive. Cognitive outputs include subject-specific as well as general improvements in abilities and knowledge and are typically measured by achievement test scores and grades. Noncognitive outputs include changes in attitudes, interests, preferences, and values; degree of socialization; and other similar affective outputs.³ Also, it is generally held that an important output of educational institutions for young children in addition to education itself is the custodial service provided for the young children.

Noncognitive outputs are not as easily identified and measured as cognitive outputs. However, it may be argued that at progressively

² Some economists, such as Leibenstein (1966), argue that the situation is no different in a conventional firm. Different groups in a firm have different interests, and game-theoretic techniques may be used to analyze possible outcomes.

³ For a discussion of the various cognitive and noncognitive outputs of the educational process, see Bloom (1956a, 1956b).

higher levels of education, as attitudes and interests become more set, the relative importance of noncognitive outputs tends to decline. Thus, it is possible that noncognitive outputs may be less important in secondary and higher educational production processes.⁴

This chapter will not consider the important question of whether the educational outputs thus defined and measured are potentially useful to the individual or the society. The main concern here is with the narrower question of how these educational outputs can be achieved through the educational production process. Also, the phenomena of dropping out, repetition, and continuation will not be considered here as direct educational outputs of the educational production process, although their occurrence may well be influenced by the degree of success in educational production.⁵

Finally, while certain educational inputs such as teacher lecturing time may be considered public goods insofar as the educational production of each individual student is concerned, the production of the educational outputs of different students in the same class will not be explicitly recognized as a joint production process.⁶ The focus of this chapter is on the educational production function at the level of the individual student.

Educational Inputs

The inputs distinguished in the empirical analysis of educational production functions may be broadly classified into five categories: (1) Home Resources, (2) School Resources, (3) Community Characteristics, (4) Student Resources, and (5) Peer-group Characteristics. Within each category, one may distinguish between inputs that are truly inputs in a technological sense, such as teacher time input, and inputs that are merely "attributes" or "labels," which cannot be readily varied by the educational producer. Examples of the latter inputs are home background variables such as "father's occupation," school characteristic variables such as "college preparatory," or student characteristic variables such as "sex." Such inputs will be referred to as permanently fixed inputs. The purpose of including these fixed "inputs" in an educational production function is to allow the technology of

⁴ There are some economists and educators who argue that the noncognitive outputs are in fact the most important outputs of the educational system. See Bowles and Gintis (1976).

⁵ See Jamison (1977) for an interesting model of the educational process that explores the interrelation between educational production and dropout, repetition, and continuation decisions.

⁶ Brown and Saks (1975) are the first researchers to have modeled such processes. See also Jamison, Fletcher, Suppes, and Atkinson (1976).

educational production to vary with different environments (home backgrounds), different orientation (school types), and different raw materials (student characteristics).⁷

Within technological inputs, one may further distinguish three types: inputs that are fixed even in the long run, such as basic school facilities and school type; inputs that are variable in the long run but fixed in the short run, such as teachers with particular attributes; and inputs that are variable in the short run, such as teacher or student time inputs. As pointed out earlier, the variable inputs are not under the complete control of a single manager but are affected by the actions of all the actors.

We shall now list many of the "inputs" that may be included in an educational production function under the five broad categories.

Home Resources

Home background. Home background includes variables such as IQ, age, education, income, occupation (possibly measured on an SES scale), race, religion, attitudes, expectations, preferences, values of either or both parents, the structure and stability of the family, the number of siblings, and locational stability. Home background variables may also include indicators of the home environment such as possession of books, radios, and television sets; frequency of travel; and knowledge of foreign languages. Of course, these possessions per se cannot make a difference, but they are used as indicators of the nature of the home learning environment.

Home inputs. Home inputs include the *direct* contribution of the time of either or both parents, older siblings, and possibly a tutor to the educational production process of the student.

School Resources

School characteristics. School characteristics include such variables as type of school (public, parochial, or other private), type of curriculum (general, college preparatory, vocational, etc.), level (elementary, secondary, etc.), size and composition of enrollment, and possibly method of instruction.⁸

School inputs. School inputs include such variables as facilities—structures, laboratories, libraries, equipment, gymnasiums, etc.;

⁷ This is strictly analogous to the possibility that the technology of agricultural production in a desert may be different from that in a river delta or that the technology may be different with the use of different seeds. See the discussion of "aptitude-treatment interaction" in Cronbach and Snow (1977) and Levin and Snow (1972).

⁸ For example, one may distinguish between "mastery learning" (see Block, 1971) and a more traditional method of instruction.

administrators—quantity, quality (including prior education and achievements), experience, attitudes and other attributes, and administrator time inputs in various activities; and teachers—quantity, quality, experience, attitudes and other attributes (including possibly IQ and verbal aptitude, knowledge of subject, ability to communicate, responsiveness to questions), and teacher time inputs in preparation, lecturing, student consultation, grading, etc. Also part of the school inputs is the choice of the method of instruction—traditional instruction, instructional radio, instructional television, instructional films, tapes, and discs, computer-assisted instruction, or some combination of the above methods.

Community Characteristics

These variables measure the degree of support that education enjoys from the community. The category may include community characteristic variables such as type of neighborhood, size of city, degree of community interest, attitudes, and average age, education, income, SES, and property value. The peer-group variable used in the empirical analysis of educational production is sometimes considered to be a community characteristic variable.

Student Resources

Student characteristics. Student characteristics include such variables as measures of innate ability (IQ), age, aptitudes, race, sex, birth order, and previous educational achievements (e.g., pretests). They also include variables measuring attitudes, interests, motivation, self-estimate, self-expectation, and values. Another set of variables that are not inputs in the proper sense but nevertheless affect the level of educational achievement is the values of alternative opportunities.

Student inputs. Student inputs include time inputs allocated among classroom attendance, homework, laboratory, self-study, etc.⁹

Peer-group Characteristics

The achievement of an individual student may depend on the collective pattern of achievement or expected achievement of the whole class. It is possible that students within a class may be able to provide mutual help. It is also possible that the behavior of the

⁹ Wells (1973) has argued that the quality of the time input is just as important as the quantity of the time input. However, an independent measure of the quality of the time input is not available. But as long as the effectiveness of an hour of time input of a student is allowed to vary with his or her ability and interest, the quality dimension is adequately captured. Thus, additional quality of time input variables will not be included in this analysis.

teacher may depend on the characteristics of the class. Thus some variables measuring the aggregate characteristics of the class may be important.

The above list by no means exhausts all of the variables that may be included as "inputs" in an educational production function, but it does include most of the common ones. Some further disaggregation is possible; for example, the teacher attributes or the time inputs may be disaggregated by subject.

THE EMPIRICAL EXPERIENCE

In this section an attempt is made to summarize the experience of empirical estimation of educational production functions to date. The purpose is not to provide a comprehensive survey of the research but to give an impression of the general nature of the empirical results. Two excellent surveys—Averch, Carroll, Donaldson, Kiesling, and Pincus (1974) and Jamison, Suppes, and Wells (1974)—are available. In addition, the results of the "International Association for the Evaluation of Educational Achievements" (IEA) studies of mathematics, science, literature, reading comprehension, English and French as foreign languages, and civic education in 28 countries have been summarized by Postlethwaite (1973) and by Walker (1976). These same IEA studies are critically reviewed by Inkeles (1977). Simmons and Alexander (in press) present a survey of educational production function research in developing countries. Wells (1976) presents a survey of studies evaluating the effectiveness of educational technology alternatives to traditional instruction.

More recent studies that are not included in the surveys mentioned above include, for example, Jamison (1977), Klees (1974, 1976), Levin (1974, 1976), Mayo, Hornik, and McAnany (1976), Murnane (1974, 1975), Summers and Wolfe (1975), and Wiley (1973).

Almost every empirical estimation of the educational production function uses an achievement test score or other similar variable on the left side. In most cases only a single educational output is distinguished.¹⁰ The functional form used is primarily linear or linear-logarithmic.¹¹ The method used is predominantly ordinary least squares, although in a number of cases a simultaneous equations method such as two-stage least squares is employed. A number of

¹⁰ In some cases there may be more than one educational output, but the noncognitive output is assumed to enter recursively into the production function.

¹¹ With the exception discussed in the section below dealing with problems in empirical implementation.

studies also estimate a "reduced form" or "quasi-reduced form" equation.

The data base used in these empirical estimation exercises can be classified along three dimensions.¹² The first dimension is the degree of aggregation. Data can be available at the level of the individual student, class, grade, school, school district, metropolitan area, or state. The degree of aggregation of the data is not necessarily the same on the output side and on the input side. It may be possible in some cases to obtain achievement test scores at the individual student level but teacher quality variables only at the school level. Of course, ideally one seeks data at the individual student level when possible. Use of aggregate data on either the output side or the input side tends in general to obscure relationships even when they exist (see, e.g., Brown & Saks, 1975).

The second dimension has to do with the temporal structure. The data base may be a single cross-section, a single time series (also referred to as longitudinal data), two successive cross-sections (typically before and after an intervention or planned variation), or a time series of cross-sections (panel data). Panel data are probably the best type of data for the estimation of educational production functions because they permit the identification and estimation of individual specific effects as well as the dynamic structure of educational production. However, such data are scarce. Most of the empirical estimates of educational production functions are based on either a single cross-section or successive ones. If only a single cross-section is available, it is crucial to have a good measurement of the initial endowment, e.g., a pretest score. Without a measurement of the initial endowment, cross-sectional results are probably not particularly informative (Luecke & McGinn, 1975).

The third dimension has to do with the data generation mechanism, which may be natural, quasi-experimental,¹³ or planned variation.¹⁴ Generally speaking, the last two types of data base tend to allow a better identification of the educational production function.

The findings of all these empirical estimations of educational production functions are not always consistent, either within studies or

¹² This classification was suggested by Dean Jamison.

¹³ Quasi-experimental refers to a situation in which only a subset of the relevant factors can be controlled by the experimenter. See the discussion in Campbell and Stanley (1966).

¹⁴ Planned variation refers to a situation in which the different treatments are assigned to the subjects not on a random basis but in accordance with the preferences of the subjects. However, the treatments themselves are fixed and cannot be altered by the subjects. For a discussion of this approach, see Rivlin and Timpane (1975).

across studies. However, cumulative experience of the last 15 years of empirical research around the world seems to suggest the following regularities.

First, variations in cognitive achievement are highly correlated with variations in home background variables. Similar regularities have been observed by Averch et al. (1974), Jamison et al. (1974), the IEA studies, and Simmons and Alexander (in press). This is one of the most consistent empirical findings in the educational production function literature. However, it is difficult to interpret because home background variables are almost always highly correlated with student innate ability variables (possibly through genetic transmission). Thus, one may be unable to separate the effect of the home learning environment from the effect of student innate ability.

Carroll's (1975) study of the teaching of French as a foreign language in eight countries is a notable exception. He finds that home background, especially the socioeconomic status (SES) variable, is not always important in explaining cognitive achievement in French when a word-knowledge test variable is included as a control. Presumably the word-knowledge test variable provides a measure of the student's verbal aptitude. This finding seems to suggest that the effect of home background, holding innate ability constant, is limited by the amount of potential learning that can take place at home. On a subject such as a foreign language, which neither parent has knowledge of, the home learning environment is not likely to have much impact except through influencing the general level of student interest. It can be argued that in subjects like reading comprehension and arithmetic, the potential for learning in the home is considerable, especially for young children. However, such potential is expected to diminish as the student moves into more difficult and specialized topics. This is also consistent with the finding that home background generally diminishes in importance in higher grades.¹⁵

Second, there is no consistent relationship between cognitive achievement and class size. In fact, more often than not, any effect of class size or teacher-student ratio is found to be absent. Again, there are problems in interpreting this result. It is possible that class size is determined with reference to teacher and student quality. For example, better teachers may be assigned larger classes, or duller students may be assigned to particular classes.¹⁶ The overall consequence is to

¹⁵ However, the latter phenomenon can also be explained by selective retention, so that students in higher grades have more homogeneous home backgrounds. It may also be taken as evidence that the cumulative effect of past education has finally overtaken the effect of the home background variable.

¹⁶ This was found, for instance, by Husén (1967, p. 263).

confound the independent class size effort, if any exists. Of course, the inconsistency among studies may be due to inadequate control or noncomparable measurement of educational inputs, or to an unnecessarily restrictive specification. However, it is also possible that the effect of class size on educational production is manifested as an influence on noncognitive outputs.¹⁷ As long as noncognitive outputs are not included in the analysis, it may be difficult to find an effect for class size.

Third, there is no consistent relationship between cognitive achievement and various dimensions of teacher quality (verbal aptitude, experience, etc.), although in a number of recent studies, especially those in which the qualities of specific teachers can be matched to the individual students they teach, teacher quality variables have been found to be consistently more effective. A large number of studies surveyed by Averch et al. (1974) and Jamison et al. (1974) found teacher quality to be important, although a similar number of studies surveyed by them found otherwise. More recently, the IEA studies also have given conflicting evidence on teacher quality variables.¹⁸ The same is true of Simmons and Alexander (in press). Summers and Wolfe (1975) found teacher quality to be important and Murnane (1974, 1975) found teacher experience to be important. Again, the results must be interpreted with care. For example, if there is a systematic assignment of better teachers to duller students, the effect of teacher quality variables can once more be confounded.

Fourth, there is no consistent relationship between cognitive achievement and teacher attitudes. However, a number of studies surveyed in Averch et al. (1974), Jamison et al. (1974), and Simmons and Alexander (in press) found that teacher attitude and teacher motivation can be important. The IEA studies reach similar conclusions. It also has been suggested that teacher behavior rather than teacher quality or teacher attitude is the most important determinant of the cognitive achievement of a student.¹⁹

Fifth, student *time inputs* are important determinants of cognitive achievement. This is probably one of the most important findings of the IEA studies. Student exposure, in terms of attendance, length of

¹⁷ There is reason to think this may be the case with the education of young children.

¹⁸ However, the IEA studies also reveal substantive differences in cognitive achievement across students in developed and developing countries. One cannot help surmising that this may be due to differences in school resources such as teacher-student ratio and teacher quality.

¹⁹ See, for example, Rosenshine (1971). Murnane (1974, 1975) also emphasizes this point.

time of study, quantity of homework, etc., has been found to be important in explaining cognitive achievement in English as a foreign language, French as a foreign language, mathematics, reading comprehension and science, among others. Wiley (1973) and Summers and Wolfe (1975) also find attendance to be important. Henderson, Mieszkowski, and Sauvageau (1976) find a negative and statistically significant correlation between the number of days absent and achievement test score. Simmons and Alexander (in press) also find student exposure variables to be important in their survey of educational production function studies in developing countries.²⁰ The importance of time inputs has long been recognized by some educators (see Carroll, 1963; Bloom, 1964, 1974). However, it should be noted that attempts to replicate some of the findings reported here have not been uniformly successful (see, e.g., Karweit, 1976).

Sixth, student attitude variables include expected achievement, degree of interest, and self-estimate. The IEA studies (e.g., Carroll, 1975; Lewis & Massad, 1975; Thorndike, 1973) indicate that these variables can have an important impact on cognitive achievement.

None of these rather general conclusions constitutes a startling reversal of any of the findings of earlier surveys. In fact, the conclusion of no consistent observed relationship between cognitive achievement and school resources appears to hold quite well. The only relatively new addition is perhaps the observed importance of student time inputs in educational production, for which a substantial amount of evidence has been accumulated over the past few years.

THEORETICAL ASPECTS OF EDUCATIONAL PRODUCTION

In order to enhance the understanding of the empirical estimates of educational production functions, the discussion will turn briefly to certain theoretical aspects of the educational production process. Unfortunately, there is not at present a sufficiently well developed theory of learning that explains the process of acquisition and retention of knowledge to guide one in formulating a theory of educational production. However, the lack of such a theory of learning, per se, does not necessarily preclude the identification of the technological relationship between educational outputs and inputs, just as the lack of a

²⁰ See also Wiley and Harnischfeger (1974). The importance of student exposure is confirmed also by many empirical studies of alternative educational technologies. See Wells (1976).

precise knowledge of engineering does not preclude the identification of production functions in economics.

The educational "inputs" may be separated into three groups: those that are either permanently fixed or fixed in the long run, which will be referred to as Z ; those that are fixed in the short run and variable in the long run, which will be referred to as K ; and those that are variable in the short run, which will be referred to as X . The vector of educational outputs will be identified as Y .

The quantities of the short-run and long-run variable inputs (the latter are the same as the short-run fixed inputs) are subject to control. However, they are not controlled directly by a single educational producer. The various actors in the educational process—administrators, teachers, parents, the student—can all vary the inputs under their immediate control (e.g., the level of total time inputs and the allocation of the time inputs to the different activities) and they do so in accordance with their individual abilities, attitudes, preferences, and constraints, and in response to the choices made by one another.²¹ Leaving aside the question of whether it is possible to achieve a degree of commonality of purpose in these individual choices, one may consider the purely technical concept of the set of educational production possibilities of a student.

The Set of Short-run Educational Production Possibilities

In the short run, given class assignments, inputs such as the qualities of a teacher may be regarded as fixed as far as an individual student is concerned. What may be varied are the time inputs of the various actors in the educational production process. Given the fixed "inputs" Z and the short-run fixed "inputs" K , one can define a short-run educational production plan $\begin{bmatrix} Y \\ X \end{bmatrix}$ where Y is a vector of quantities of educational outputs (cognitive and noncognitive) and X is a vector of quantities of variable inputs, consisting of the time inputs of administrators, teachers, parents, and the student himself, possibly further disaggregated by the type of activity (classroom attendance, homework, etc.). A short-run educational production plan is said to be feasible if the vector of educational outputs can in fact be achieved by the vector of short-run variable inputs, given the short-run, long-run, and permanently fixed inputs. The set of feasible educational production plans, for given Z and K , is referred to as the set of

²¹ One may argue that parents and teachers have at least partial control over a student's time inputs.

educational production possibilities for given $\mathbf{Z}$ and $\mathbf{K}$, or $T(\mathbf{Z}, \mathbf{K})$. The set T may change with changes in $\mathbf{Z}$ and $\mathbf{K}$.

It is assumed that the set of educational production possibilities has the following properties:

1. **Nonemptiness.** For each $\mathbf{Z}$ and $\mathbf{K}$, the set of educational production possibilities $T(\mathbf{Z}, \mathbf{K})$ is nonempty. In particular, the origin belongs to $T(\mathbf{Z}, \mathbf{K})$. Nonemptiness of the set of educational production possibilities merely means that it is possible to find a vector of variable inputs that is associated with a vector of educational outputs, given the fixed inputs. The inclusion of the origin in the set means that it is possible to choose the production plan corresponding to inaction.

2. **Closure.** The set of educational production possibilities is closed. Closure implies that the set of educational production possibilities contains all of its boundary points. In practice this is an innocuous assumption.

3. **Convexity.** The set of educational production possibilities is convex. Convexity implies that if $\begin{bmatrix} \mathbf{Y}_1 \\ \mathbf{X}_1 \end{bmatrix}$ and $\begin{bmatrix} \mathbf{Y}_2 \\ \mathbf{X}_2 \end{bmatrix}$ are both feasible educational production plans, then the educational production plan $\begin{bmatrix} (1 - \lambda)\mathbf{Y}_1 + \lambda\mathbf{Y}_2 \\ (1 - \lambda)\mathbf{X}_1 + \lambda\mathbf{X}_2 \end{bmatrix}$ is also feasible, for any scalar λ , $0 \leq \lambda \leq 1$. In other words, if one can achieve $\mathbf{Y}_1$ with $\mathbf{X}_1$, and $\mathbf{Y}_2$ with $\mathbf{X}_2$, then one can achieve a weighted average of $\mathbf{Y}_1$ and $\mathbf{Y}_2$ with a similarly weighted average of $\mathbf{X}_1$ and $\mathbf{X}_2$.

4. **Nonnegativity.** The set of educational production possibilities is contained in the nonnegative orthant. Nonnegativity implies that a feasible educational production plan must have all educational outputs and inputs nonnegative.

The Short-run Educational Production Function

Given a set of short-run educational production possibilities we can now derive the short-run educational production function. The educational production function represents the boundary of the set of educational possibilities. One may define the educational production function in terms of any one of the educational outputs (or, for that matter, in terms of any one of the variable inputs). Without loss of generality, we shall define the educational production function in terms of the $(n + 1)$ st educational output, Y_{n+1} . The educational production function, for fixed $\mathbf{Z}$ and $\mathbf{K}$, is then a function of the quantities of the first n components of $\mathbf{Y}$, which we shall denote $\mathbf{y}$, and $\mathbf{X}$. It gives the maximum value of Y_{n+1} , for given values of $\mathbf{y}$ and $\mathbf{X}$ and fixed

Z and K , such that $\begin{bmatrix} Y \\ X \end{bmatrix}$ is contained in $T(Z, K)$. Thus, formally,

$$(1) \quad \begin{aligned} Y_{n+1} &= \text{Max} \left\{ Y_{n+1} \mid \begin{bmatrix} Y \\ X \end{bmatrix} \in T(Z, K) \right\} \\ &= F(y, X; Z, K). \end{aligned}$$

An educational production function thus derived has certain properties that are implied by the properties of the set of educational production possibilities.²²

1. **Domain.** $F(y, X; Z, K)$ is defined on a convex subset of the nonnegative orthant which contains the origin for every Z and K .

2. **Nonnegativity.** $F(y, X; Z, K) \geq 0$.

3. **Closure.** $F(y, X; Z, K)$ is upper-semicontinuous in y and X .

4. **Concavity.** $F(y, X; Z, K)$ is concave, in y and X . Concavity implies diminishing marginal rates of substitution and transformation. Concavity together with closure implies that the educational production function is actually continuous in y and X . In empirical estimation, it is often assumed that the production function is differentiable.

Any set of educational production possibilities with properties 1 through 4 gives rise to an educational production function with properties 1 through 4. Conversely, given a production function

$$Y_{n+1} = F(y, X; Z, K)$$

with properties 1 through 4, one can derive the set of educational production possibilities as

$$T(Z, K) = \left\{ \begin{bmatrix} Y \\ X \end{bmatrix} \mid 0 \leq Y_{n+1} \leq F(y, X; Z, K), \ 0 \leq y, \ 0 \leq X \right\}.$$

It is a central fact of the theory of production that there is a one-to-one correspondence between sets of production possibilities with properties 1 through 4 and production functions with properties 1 through 4, so that any such set of production possibilities derived from a production function must coincide exactly with the original set of educational production possibilities. Moreover, it can be shown that the set of educational production possibilities is invariant with respect to whichever educational output or variable input one chooses to be

²² For the derivation of a production function from a set of production possibilities, see, for instance, Jorgenson and Lau (in press).

the left-hand-side variable of the production function. Thus, even in the case of multiple educational outputs, as long as the properties 1 through 4 of the set of educational production possibilities are satisfied, there is a unique educational production function

$$Y_{n+1} = F(y, \mathbf{X}; \mathbf{Z}, \mathbf{K}).$$

One difference between this educational production function and the conventional single-output educational production function is that the other educational outputs also appear on the right-hand side.

Note that no monotonicity assumptions have been made. One may, of course, impose monotonicity assumptions on the set of educational production possibilities (or equivalently, on the production function). The dependence of the set of educational production possibilities and hence the production function on the fixed inputs $\mathbf{Z}$ and $\mathbf{K}$ is allowed to be perfectly general. For example, the production functions corresponding to different $\mathbf{Z}$ and $\mathbf{K}$ can be totally different. This illustrates the generality of this approach. One may, of course, also impose a monotonicity assumption on the dependence on $\mathbf{Z}$ and $\mathbf{K}$.

The educational production function in Equation 1 is quite different from the customary empirical educational production function even if y is omitted from the right-hand side. First, assume that there is only one educational output, so that the educational production function becomes:

$$(2) \quad Y_1 = F(\mathbf{X}; \mathbf{Z}, \mathbf{K}).$$

Assume further that $\mathbf{X}$ represents time inputs. But in practice, $\mathbf{X}$ is not observed in most empirical studies of educational production, so that it is often assumed that $\mathbf{X}$ depends on the characteristics, attitudes, and constraints of all the actors in the process, as well as on $\mathbf{Z}$ and $\mathbf{K}$, and that this dependence is of the same nature across students. Thus, each component of $\mathbf{X}$ is a function of $\mathbf{Q}$, a vector of characteristics, attitudes, and constraints of all actors, and $\mathbf{Z}$ and $\mathbf{K}$.²³ One may write, in vector notation, $\mathbf{X} = g(\mathbf{Q}, \mathbf{Z}, \mathbf{K})$. Substituting this into Equation 2, we obtain:

$$(3) \quad Y = F(g(\mathbf{Q}, \mathbf{Z}, \mathbf{K}); \mathbf{Z}, \mathbf{K})$$

which with an appropriate choice (frequently linear or linear-logarithmic) of the algebraic specification is often the form in which

²³ The vector $\mathbf{Q}$ may contain some components that are also contained in $\mathbf{Z}$ and $\mathbf{K}$.

an educational production function is estimated. However, a function such as the one in Equation 3 must be interpreted very carefully. Taken by itself it does not identify the technological relationship in Equation 2. Instead, it is a "reduced form" relationship which takes into account both the educational technology and the behavior of all the actors in the educational process.²⁴ Additional information is needed to identify the technological relationship between educational outputs and inputs. Thus, a knowledge of the dependence of Y on Z and K as in Equation 3 may throw little light on the dependence of Y on Z and K as in Equation 2. In particular, any prior notions on the directions of dependence of the production function on Z and K cannot, in general, be validated on the basis of an estimated Equation 3 alone.

It is possible that part of the X vector is observed. Denote the part that is observed as X_1 and the other part as X_2 ; then Equation 2 becomes, by a similar process,²⁵

$$(4) \quad Y = F(X_1, g(X_1, Q, Z, K); Z, K).$$

Again, a knowledge of Equation 4 may throw little light on the educational production function. For example, let X_1 be the teacher's time input and X_2 be the student's time input. Suppose that the educational production function is increasing in both variables. However, if the student's attitudes and interests are such that he (or she) has a fixed aspiration level, then the more time the teacher puts in, the less time the student will put in, other things being equal, so that the $g(X_1)$ function is decreasing in X_1 . Overall then, a function such as the one in Equation 4 may show no dependence on X_1 .²⁶

In the case of multiple educational outputs, a similar argument applies. It may be assumed that there exists a process (possibly unknown and often unspecified) of determining the "desired" combination of the different educational outputs. The process depends, of course, on the characteristics, attitudes, and constraints of the actors. Suppose that one may write $y = h(Y_{n+1}, X, Q, Z, K)$; then by substituting this back into Equation 1, one obtains:

²⁴ In particular, it is based on the crucial assumption that the behavior of any of the actors is perfectly determinate given the actor's identifiable characteristics, attitudes, and constraints.

²⁵ It is assumed that the choices of X_2 depend not only on Q, Z , and K but also on the choices of X_1 .

²⁶ A function such as the one in Equation 4 is sometimes referred to as a "quasi-reduced form."

$$(5) \quad Y_{n+1} = F(h(Y_{n+1}, \mathbf{X}, \mathbf{Q}, \mathbf{Z}, \mathbf{K}), \mathbf{X}; \mathbf{Z}, \mathbf{K}).$$

From Equation 5, one may apply the implicit function theorem to solve Y_{n+1} in terms of the remaining variables, to obtain:

$$(6) \quad Y_{n+1} = G(\mathbf{X}, \mathbf{Q}, \mathbf{Z}, \mathbf{K}).$$

Again, Equation 6 does not represent a technological relationship and may in fact bear little resemblance to the technological relationship in Equation 1.

This lack of identification is a problem that plagues a substantial proportion of empirical studies of educational production. In principle, this problem is not insurmountable. It does require, however, the collection of detailed student-specific data on the quantities of variable inputs including possibly detailed time budgets of the actors, and a concomitant analysis of the behavioral patterns of the actors in the educational process.²⁷

One possible specialization of Equation 1 is:

$$(7) \quad Y_{n+1} = F(y, f(\mathbf{X}; \mathbf{Z}, \mathbf{K}))$$

where f is a real-valued function. Equation 7 implies that outputs and inputs are separable and can be rewritten as:

$$(8) \quad G(\mathbf{Y}) = f(\mathbf{X}; \mathbf{Z}, \mathbf{K}).$$

$G(\mathbf{Y})$ may be considered as an index of educational outputs which aggregates across the different educational outputs, and Equation 8 itself may be considered as a single-output production function if $G(\mathbf{Y})$ is known. However, to justify the specialization from Equation 1 to Equation 8, one must assume that the composition of the outputs does not affect the composition of the inputs, and vice versa. This assumption has not been found to be realistic in production studies in economics in general. Whether it is realistic in educational production can only be determined empirically.

A Digression on Frontier Estimation

It has been argued, by Levin (1974, 1976) and others, that since the production function is by definition the *maximum* quantity of the

²⁷ A number of researchers have already adopted the systems approach to the empirical analysis of educational production functions. See, for example, Adelman and

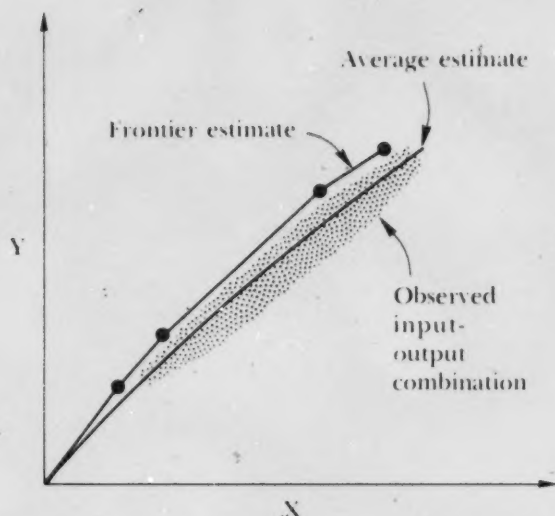


FIGURE 1. Comparison of frontier estimate and average estimate.

$(n + 1)$ st educational output achievable given the quantities of the remaining n educational outputs, the variable inputs, and the fixed inputs, it should be estimated as the *outside* boundary of the observed input-output combinations (hereafter referred to as the frontier estimate) rather than as the best-fitting surface through all of the observed input-output combinations (hereafter referred to as the average estimate). The difference of the two estimates in the single-output, single-input case is illustrated in Figure 1.

The two alternative estimates of an educational production function can differ substantially (see Levin, 1974, 1976). Whether one or the other estimate is to be preferred depends on one's assumptions about the behavior of the educational producer, on the stochastic nature of the production function, and on the errors of measurement. First, from the behavioral point of view, a standard argument in favor of the frontier estimate is that since educational producers do not have any incentive to optimize, they are just as likely to operate at a point on the boundary of the set of production possibilities as at an arbitrary point in the interior of the set of production possibilities. Yet

Parti (n.d.), Boardman, Davis, and Sanday (1973), Carnoy and Levin (1970), Jamison (1977), Levin (1970), and Wells (1973).

the lack of an intention or a failure to optimize does not in itself necessarily imply that resources will be under-utilized. On the contrary, as long as there is an alternative use for the resources, there will be a tendency for a producer to operate close to the production function, if not actually on it. For example, an administrator who is primarily interested in his or her own comfort may try to operate efficiently so that resources may be reallocated to satisfy his or her personal desires. Divergent interests within the educational institution itself may also have the effect of enforcing the full utilization of resources. For example, the athletic program and the science program may compete with each other for resources. Thus, it is quite conceivable for an educational producer to operate efficiently in the sense of being on the production function without operating or even attempting to operate optimally. Finally, the individual students may also attempt to minimize their individual efforts to achieve any given level of educational output. This minimization on their part will again tend to keep the observed input-output combinations on the individual production functions.²⁸

Second, from a stochastic point of view, in order to justify the frontier estimate, one normally must assume that the production function is perfectly deterministic and known with certainty by the educational producers and that all the deviations of the actual observations from the production function are caused by inefficiencies. On the other hand, one may look upon these deviations as basically random phenomena reflecting (a) random fluctuations of test performance of an individual student with a given level of achievement, (b) random differences in the unmeasured abilities of the educational producers or students, and (c) randomly distributed differences in production functions. This interpretation of the deviations tends to support the use of the average estimate.

Finally, the potential for errors of measurement in the observations of both outputs and inputs is particularly large in educational production. Test scores, which are frequently used as measures of educational outputs, are subject to well-known reliability limitations. Likewise, many of the inputs, such as teacher quality and student initial endowment, are subject to large margins of error. Given the presence of all these errors, the frontier interpretation of the *actual* observations may seem unrealistic. In addition, the frontier estimate is likely to be quite sensitive to large errors. Based on these considerations, the use of the average estimate of an educational production function can still be fully justified under a variety of circumstances.

²⁸ However, just being on the boundary of the set of production possibilities does not necessarily imply efficiency in the allocation of educational resources.

The Long-run Educational Production Function

In the long run, for each given Z , the short-run fixed inputs, K , may be varied. If, for each Z , K can be varied continuously, then one can trace out a long-run educational production function as a function (not necessarily continuous or concave) of y , X , and K . If, for each Z , K can take only discrete values (e.g., K may be the indicator of the type of school), then under the additional assumption of convexity, one can derive the set of long-run educational production possibilities as the convex hull of the union over K of all the sets of short-run educational production possibilities. The long-run educational production function is then given by the boundary of the set of long-run production possibilities.

Empirically, whether one can trace out the complete long-run educational production function depends on the range of observed variations of K for each given Z . If for each Z , the range of variation of K is limited, as will be the case if there exists a subsidiary relationship between K and Z (e.g., class size and student ability), then it may not be possible to identify fully the long-run educational production function.

A Dynamic Model of Educational Production

So far, the discussion has been entirely static. No time subscripts are attached to any of the outputs and inputs. X is assumed to stand for the *cumulative quantities* of the inputs employed during the particular period of production. Y is assumed to stand for the quantities of educational outputs at the end of the period of production. Z and K , being fixed throughout the period of production, are assumed to take their values at the beginning of the period. The vector Z may include pretests and other measures of initial endowment.

The concept of the educational production function will now be extended to a dynamic context. For the sake of simplicity, the discussion will be restricted to the single-output, two-period case, although the results can be generalized to a multiple-output, multiperiod case.

In a single-output, two-period model, the educational production function can be written as:

$$(9) \quad Y_2 = F(Y_1, X_1, X_2; K_1, K_2, Z)$$

where the subscripts refer to the period. Note, first of all, that even if X_2 and K_2 are both zeros, it does not necessarily follow that Y_2 is zero.

$$(10) \quad Y_2 = F(Y_1, X_1, 0; K_1, 0, Z).$$

Equation 10 describes the time profile of cognitive achievement, given inputs in the first period only. In other words, it shows how cognitive achievement is retained over time. Note that the quantity of achievement retained in the second period, given a *fixed* Y_1 , may change with the quantities of inputs employed in the first period.

At least two important specializations of the dynamic educational production function in Equation 9 may be identified. The first specialization is based on the capital-embodiment assumption introduced by Hanushek (1972) and Levin (1970). Under this assumption, output at any point in time is a function of the inputs cumulative to that point in time. In other words, Equation 9 may be replaced by two equations:

$$(11) \quad Y_1 = F(\mathbf{X}_1; \mathbf{K}_1, \mathbf{Z})$$

$$(12) \quad Y_2 = F(\mathbf{X}_1 + \mathbf{X}_2; \mathbf{K}_1 + \mathbf{K}_2, \mathbf{Z}).$$

It is apparent from Equation 12 that, insofar as Y_2 is concerned, it does not matter in which period the $\mathbf{X}$'s or $\mathbf{K}$'s are employed, as long as the cumulative quantities are the same. In other words, inputs of the first period are perfect substitutes for inputs of the second period, and vice versa. This assumption of perfect substitutes implies that a student can make up the deficiency in inputs in the first period by an appropriate choice of inputs in the second period.²⁹ The second specialization is based on the recursivity assumption. Under this assumption, output at any point in time is a function of the inputs of the immediately preceding period of production and the output at the beginning of the immediately preceding period. In other words, Equation 9 may be replaced again by two equations:

$$(13) \quad Y_1 = F(\mathbf{X}_1; \mathbf{K}_1, \mathbf{Z}, Y_0)$$

$$(14) \quad Y_2 = F(\mathbf{X}_2; \mathbf{K}_2, \mathbf{Z}, Y_1)$$

where Y_0 is a pretest score. It is apparent from Equation 14 that Y_2 depends on $\mathbf{X}_1$ and $\mathbf{K}_1$ only through Y_1 . The latter variable thus summarizes all effects of past history. An implication of the model based on the recursivity assumption is that a specific input does not have any *uniquely identifiable, permanent* effects beyond the period in which it is employed. All its effect works through the achievement test

²⁹ One can introduce discount factors in the cumulation. However, the implication remains basically unchanged.

score at the end of the period. For example, whether a student has had a good teacher and a bad curriculum or a bad teacher and a good curriculum in the first grade can have no permanent effect on the student's future level of achievement as long as the achievement test score at the end of the first grade is the same.

Note that both of these models are genuine specializations. For example, neither of the models can capture the idea that a good head start in a specific input (e.g., a high level of X_1) can have a direct *permanent* effect on cognitive achievement in all future years. Nor do they allow intertemporal interactions between the same inputs and across inputs (e.g., time inputs in mathematics for the last period may increase the marginal product of time inputs in physics of this period, holding last period's test scores constant). Whether either of the two specializations is realistic can only be determined empirically. Finally, it should be added that true peer-group effects are difficult to model except perhaps in a dynamic context. For an attempt to measure peer-group effects, see Henderson et al. (1976).

To conclude this section on theoretical aspects of educational production functions, one may note that it is in general necessary to consider explicitly the behavior of all the actors in the educational production process in order to identify the educational production function. The only exception to this rule is when all the outputs and inputs can be experimentally controlled. It seems highly unlikely though, even under the best of circumstances, that all inputs, including student time inputs, can be perfectly controlled by any experimenter. Thus, one has little choice but to consider the behavior of the actors explicitly in the context of a complete model if one wishes to identify the true technological relationships.

On the other hand, if one is interested not so much in the technological relationship of educational production at the individual student level as in the net educational system responses, taking into account the induced changes in behavior on the part of all the actors as a result of changes in certain educational resources, one may bypass explicit consideration of the behaviors of the actors as long as they are stable. One may then relate the responses directly to the changes in resources. Such a relationship will resemble more the aggregate production function used in macroeconomics than the technologically based production functions used in microeconomics.

PROBLEMS IN EMPIRICAL IMPLEMENTATION

The difficulties in the econometric identification and estimation of the educational production function have been pointed out by many authors—Bowles (1970), ~~Bowles~~ and Levin (1968a, 1968b), Hanushek

(1972), Klees and Wells (1977), Levin (1970, 1975, 1976), Luecke and McGinn (1975), Michelson (1970), Simmons and Alexander (in press), and Wells (1973), to name only a few. These difficulties have cast doubt on the validity of the empirical estimates, especially those estimates derived from ordinary least-squares regression methods. Some of the more common problems will be discussed here.³⁰

Errors of Measurement

The difficulties of measuring the quantities of educational outputs and inputs are well known. While, in principle, cognitive outputs can be measured at least approximately by means of appropriately constructed tests, the same cannot be said of the noncognitive outputs; there is, in fact, no universal agreement on how the latter variables should be measured. The validity of measures of cognitive outputs such as achievement test scores has also often been questioned on the grounds that such measures may be sensitive to student cultural background, motivation in test-taking, and a host of other factors. In any case, even if all these problems are absent, any test score has only limited reliability.³¹ Similarly, inputs such as home background characteristics, student innate ability, attitudes, expectations, interest, and motivation, and various dimensions of teacher quality are also difficult to capture and measure precisely. Not infrequently the use of certain scales, such as various measures of socioeconomic status, will be questioned. Moreover, a substantial number of "inputs," such as the number of books in a home, are actually intended only as indicator or proxy variables for more basic variables, such as the condition of the home learning environment. Thus, it will be fair to say that the educational outputs and inputs *actually* used in the estimation of educational production functions do not correspond precisely to the true value of the variables that they are supposed to measure; that is, they are subject to errors of measurement.

From an econometric point of view, errors of measurement have several consequences. First, it may not be possible to identify the true educational production function relationship. Second, even if it were possible to identify the true relationship, the ordinary least-squares estimator may be biased.³² It thus calls for methods of analysis other than that of ordinary least squares. Moreover, if some variables

³⁰ Detailed treatments of many of the problems discussed here are available in many econometrics textbooks. See, for example, Goldberger (1964) or Hanushek and Jackson (1977).

³¹ For instance, a test score based on odd-number questions only may differ from a test score based on even-number questions only.

³² Such a model is often referred to as an "errors-in-variables" model.

are truly unobservable, and we can only measure indicators of these unobservable variables, alternative models other than the standard multiple regression model should be used. One such model has been developed by Jöreskog and Goldberger (1975).

Educational production function research would benefit substantially if the measurement of the basic variables were improved. This is an area in which economists generally have little competence and the contributions of educators, psychologists, sociologists, and statisticians are needed.

Specification

The specification of a model for the estimation of an educational production function includes three components: choice of variables, choice of functional forms, and stochastic specification. The choice of variables can affect the quality of an estimate. If variables that should be included are excluded, then generally the standard estimate may be subject to a bias, unless the excluded variables are orthogonal to all the variables that are included. If variables that should be excluded are included, the resulting standard estimate is unbiased; however, the precision of the estimate is reduced. Sometimes the omission of a variable is due to unavailability of data, a leading example being the noncognitive educational output. The consequences of specification errors of this type can be analyzed by the techniques developed by Griliches (1957) and Theil (1957).

The choice of functional forms may sometimes determine whether an effect may be found. Almost all of the functional forms that have been used in the empirical estimation of educational production functions are linear or linear-logarithmic.³³ Both of these functional forms have been criticized. The linear functional form has constant marginal products for each and every input independent of the levels of the inputs (and any other outputs). It has the undesirable and unrealistic implication, as pointed out by Brandl (1970), that a cost-minimizing educational producer will generally employ only one input.³⁴ The linear-logarithmic function is familiar to economists as the Cobb-Douglas function. Some of its defects have been pointed out by Bowles (1970). It has the implication that a cost-minimizing educational producer will always allocate constant shares of total expenditures to the individual inputs, regardless of the prices of the inputs.

³³ One exception is the work of Wells (1973). He experiments with the transcendental logarithmic function and the Box-Cox transformation function (also known as the constant-elasticity-of-substitution function). See also Wells and Jamison (in press).

³⁴ When more than one input is employed, the composition of the inputs can be completely arbitrary.

An additional disadvantage of the linear-logarithmic function is that it cannot be used to represent educational production processes in which more than one educational output is produced. The requirement that the transformation surface between any two educational outputs be monotonically decreasing and convex cannot be satisfied by any linear-logarithmic function.

The most important weakness of the linear or linear-logarithmic function has to do with its inability to measure certain types of effects that may be important in education. For example, if the true effect is nonlinear and has the shape depicted in Figure 2, a linear function estimate will indicate no effect. In any case, the measured effect from a linear function (or linear-logarithmic function) can be very different from the true effect. This problem becomes much more critical in educational production function research because many of the variables—outputs and inputs—do not have a natural scale as in the conventional production processes. In many instances, the educational outputs and inputs are measured only up to an order-preserving transformation. The assumption of linearity then requires us to specify that a particular cardinalization of the measured dependent variable is linearly related to a particular cardinalization of the measured independent variable. Even if such cardinalizations do exist, it is only fortuitous that one can choose the right ones from the beginning. It is thus much better to start off with a more flexible

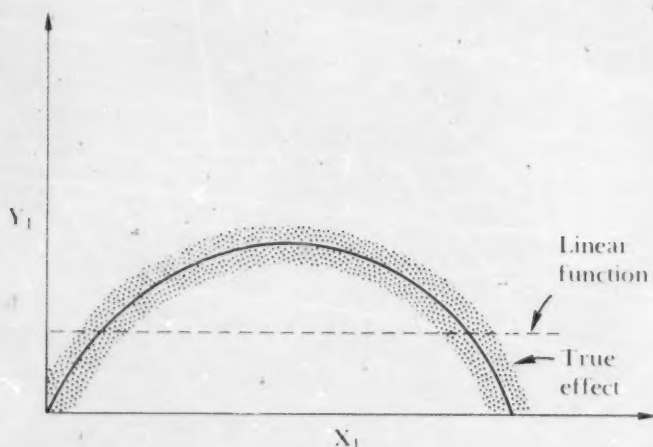


FIGURE 2. A nonlinear effect.

functional form that can represent more complex dependencies like polynomials.³⁵

Finally, linearity or logarithmic linearity imposes very strong restrictions on the possible effects of fixed inputs. To illustrate this idea, consider the single-output case. The educational production function in its most general form can be written as:

$$(15) \quad Y = F(\mathbf{X}; \mathbf{Z}, \mathbf{K})$$

where the dependence of Y on $\mathbf{X}$ can be completely different for different $\mathbf{Z}$ and $\mathbf{K}$. A specialization of Equation 15 is

$$(16) \quad Y = F(\mathbf{X}, A(\mathbf{Z}, \mathbf{K}))$$

where A is a real-valued function. Equation 16 still allows the dependence of Y on $\mathbf{X}$ to be different for different values of A , but not for different sets of $\mathbf{Z}$ and $\mathbf{K}$ which yield the same value for A . Two further specializations of Equation 16 are:

$$(17) \quad Y = F(\mathbf{X}) + A(\mathbf{Z}, \mathbf{K})$$

and

$$(18) \quad Y = A(\mathbf{Z}, \mathbf{K})F(\mathbf{X}).$$

Equation 17 says that the dependence of Y on $\mathbf{X}$ is the same for all $\mathbf{Z}$ and $\mathbf{K}$ except for the addition of A . Equation 18 says that the dependence of Y on $\mathbf{X}$ is the same for all $\mathbf{Z}$ and $\mathbf{K}$ except for a multiplicative factor of A . Assuming that F and A are linear and linear-logarithmic functions, respectively, one can obtain the linear and linear-logarithmic functions. Thus, for example, linearity basically imposes the assumption that the educational production function is identical for students with different abilities up to an additive or multiplicative effect. Moreover, linearity rules out such possible effects as teacher-student interaction a priori. If the latter were the only effect present, then the estimate of the linear function could well indicate no effect. Therefore, it may be more reasonable, in view of the limited prior knowledge of the process, to allow for more general effects.

³⁵ Note that the use of more flexible functional forms also gets around the criticism of Klees and Wells (1977), who argue that interval scales are necessary for regression analysis. This is only true if a linear or linear-logarithmic functional form is used.

Stochastic specification has not received much attention in educational production function research except in the context of the simultaneous equations model (to be discussed below). Typically, it is assumed that the errors in the educational production functions are independently and identically distributed. When the distribution is specified, it is almost always the normal distribution. One possible misspecification is that the errors may not be independently distributed, especially for students belonging to the same class or school. In addition, if peer-group effects on individual cognitive achievement are important, as some researchers believe them to be, it will be difficult to maintain the independence assumption. The standard ordinary least-squares estimate remains unbiased under the alternative stochastic assumption. However, the precision of the estimate can be improved by taking into account the nonindependence. Standard techniques exist to deal with the nonindependent case.

The stochastic specification becomes more critical if time series data or panel data are used. Here it is reasonable to assume that the errors of the same student in two successive periods may be serially correlated. Again, standard techniques exist to deal with such departures from the independence assumption.

Identification

The question of identification arises when, in addition to the educational production function, there is one or more subsidiary relationships involving one or more of the educational outputs or variable inputs. When this occurs, we have what is called a simultaneous equations system (which includes a recursive equations system as a special case).³⁶ The following example illustrates this idea. Let there be two educational outputs, Y_1 and Y_2 , so that the educational production function can be written as:

$$Y_2 = F(Y_1, \mathbf{X}; \mathbf{Z}, \mathbf{K}).$$

In addition, suppose that the educational producer has the policy of maintaining the two outputs in constant proportions, with the proportionality factor possibly dependent on some components of $\mathbf{Z}$ and $\mathbf{K}$, so that

$$Y_2 = G(\mathbf{Z}, \mathbf{K})Y_1.$$

³⁶ The system need not be complete.

Given the values of $\mathbf{X}$, $\mathbf{Z}$, and $\mathbf{K}$, the two equations, which are sometimes referred to as structural equations, then determine Y_1 and Y_2 , which are referred to as endogenous variables, simultaneously. From the proportionality relation one may solve for Y_1 in terms of Y_2 and $G(\mathbf{Z}, \mathbf{K})$. Substituting this solution of Y_1 into the educational production function, an equation defining Y_1 implicitly as a function of $\mathbf{X}$, $\mathbf{Z}$, and $\mathbf{K}$ is obtained. The function that relates Y_1 to $\mathbf{X}$, $\mathbf{Z}$, and $\mathbf{K}$ is called the reduced-form equation of Y_1 . By substituting the reduced-form equation of Y_1 back into the proportionality equation, the reduced-form equation of Y_2 is obtained. Given a production function and a proportionality relation, one can always derive reduced forms for Y_1 and Y_2 .

However, the converse is not necessarily true. Corresponding to any pair of reduced-form equations of Y_1 and Y_2 , there may be an infinity of educational production functions and proportionality relations which may have given rise to the same pair. This means that even if one is free to vary $\mathbf{X}$, $\mathbf{Z}$, and $\mathbf{K}$ in any way and any number of times and can collect observations on the resulting Y_1 and Y_2 , the educational production function and the proportionality relation still cannot be determined uniquely and unambiguously. When this happens, one may as well give up any hope of ever being able to find the true production function.

The system is identified if the reduced-form equations enable one to determine the production function and the proportionality relationship uniquely. It is then possible to obtain a unique estimate of the educational production function and the proportionality relation. Whether the system is identified or not depends on the specification of the functions F and G . Obviously, if the production function is not identified, it is not meaningful to attempt to estimate it. Identification is thus logically a prior condition for estimation of a simultaneous equations model.

Estimation

Problems are first discussed in a context in which a single-equation approach may be justified, as, for example, in a recursive equations system model. Two common problems that one may encounter are multicollinearity and limited variability of the independent variables. Multicollinearity is said to occur when one or more variables can be expressed very nearly as a linear combination of a subset of the other variables. The consequence of multicollinearity is that one cannot estimate precisely the separate effects of the linearly dependent subset of variables. This condition is especially annoying if part of the subset consists of variables that are subject to control, and part of it

consists of variables that are uncontrollable. Sometimes multicollinearity may occur as a result of a small sample size, in which case the obvious solution is to increase the sample size. Sometimes multicollinearity may occur because of sampling bias. For example, it is possible that, within certain groups, income and age may be highly correlated, but if the sample is expanded to include other groups, the high correlation of income and age may disappear. However, if the multicollinearity appears to be persistent, such as that between income and occupational status, then one may well ask whether a second subsidiary relationship may be present, or whether in fact the two variables are just two different indicators of the same condition.³⁷

Limited variability of the independent variables is said to occur when the range of variation of a single variable or a set of variables is small. In the case of a single variable, if its value does not vary at all, then it is impossible to estimate its effects. If its range of variation is small, then the estimated effect is likely to apply over only a very small range. In the case of several variables, if the range of variation of the variables taken as a group is constrained to a proper subspace of the space of the original variables, then it is again impossible to identify the separate effects. This happens when there exists one or more functional relationships, not necessarily linear, between the variables. When the functional relationships are linear, one is back in the multicollinearity case. For example, suppose brighter students are always observed in larger classes and duller students in smaller classes, then it will be impossible to identify the effects of intelligence and class size separately. In a case such as this, where one suspects the limited variability may be the result of some conscious policy, it is better to specify a behavioral equation for the determination of class size and then treat the resulting system as a simultaneous equations system.

An issue which is also related to the variability of the variables is the use and interpretation of standardized regression coefficients. These standardized coefficient estimators are in general not robust across samples and should be used in the reporting of empirical estimates of educational production functions only in conjunction with the actual regression coefficient estimates themselves (see Hanushek & Jackson, 1977).

In the simultaneous equations context, one problem is that the ordinary least-squares estimator is no longer adequate. However, there are now many feasible methods of estimation: maximum likelihood, two- and three-stage least squares, etc. Another drawback of a

³⁷ Another possible solution is to apply Bayesian estimation techniques. However, the resulting estimate is sensitive to the specification of the prior distribution of the parameters.

simultaneous equations system is that the remaining equations have to be specified. But perhaps that is really an advantage because the researcher will be forced to give some thought to the behavior of the various actors in the educational production process. When a single equation in a simultaneous equations model is estimated by ordinary least squares, the estimate is in general subject to a simultaneous equations bias, which does not disappear even if the sample size is increased indefinitely.³⁸ The only case in which ordinary least squares can be justified is if the simultaneous equations system is actually a recursive equations system. Reduced-form equations can, of course, be estimated by ordinary least squares.³⁹

Model Selection

Most of the large-scale educational production function research uses as a model-selection strategy stepwise regression or blockwise regression. Successive variables, or blocks of variables, are introduced into the regression according to a predetermined order and they are retained or dropped depending upon a preselected criterion on either the changes in the proportion of variance explained or on the values of the *t* ratios or some transformation of these basic statistics. The final estimate thus arrived at has very different properties in general than if it were the first estimate obtained. There have been very few systematic evaluations of this model-selection strategy in the educational production function literature. It does appear intuitively clear that the conventional statistical tests of significance cannot be applied uncritically to the final estimate; some adjustments of the levels of significance are necessary.⁴⁰

In the foreseeable future, however, the way in which researchers can hope to increase their understanding of the educational production process is probably not through an improved model-selection strategy, but through careful and painstaking replications of models that have already been estimated on *new* bodies of data (and estimation of new models on all old bodies of comparable data). Since in a typical study a large number of alternative models are tried, out of

³⁸ We note that the simultaneous equations bias does not necessarily disappear even though the educational producer does not maximize profits or minimize costs. So long as the educational producer's rule of allocation of outputs and inputs depends on more than one output or variable inputs and is subject to a stochastic disturbance, ordinary least-squares estimates of the educational production function can be subject to a simultaneous equations bias.

³⁹ That is, if the reduced-form parameters are unconstrained.

⁴⁰ See Kennedy and Bancroft (1971), who examine such a class of model-selection strategies.

which only "successful" trials are reported, replicability, that is, the ability to find the same results on similar data, seems to be the most reasonable basis for judging the reliability of a particular set of empirical results.

CONCLUDING REMARKS

Given the preceding discussion, one may seriously question the usefulness of the educational production function approach in view of all the difficulties involved in its implementation and interpretation. However, it should be borne in mind that the production function is a useful organizing device for the consideration of various issues in education. In addition, although many of the available estimates are in fact "reduced form" or "quasi-reduced form" estimates of the educational production function rather than the technological relationship itself, they nevertheless are capable of revealing empirical regularities, if any exist, which must eventually be explained by a more complete theory. Note that the finding of *insignificant* effects can also be an empirical regularity.

Empirical regularities can be rigorously established only if the results that they represent are replicated or at least not contradicted in repeated estimation of the same model using different bodies of data. In a research area such as that of the educational production function where the theory is neither complete nor firm, and the statistical methods not totally justified, it is important to determine whether a given finding is an empirically observed regularity or just a statistical happenstance. In the former case it deserves further theoretical and empirical investigation. In the latter case it should not be taken as seriously. Thus, replicability and interstudy consistency have an especially significant role to play at this stage of development in educational production function research.

Besides the identification and verification of empirical regularities, there are a number of potentially fruitful directions of research in the area of educational production functions. They will be discussed separately under the rubrics of theory, measurement, and empirical implementation.

Theory

First, the theoretical foundations of educational production function research will be strengthened enormously if progress can be made in the development of an engineering-type relationship between educational outputs and inputs based on a theory of learning similar to the engineering production functions in economics (see

Chenery, 1949). Specifically it is hoped that such research can shed light on (a) whether teacher time inputs in the production process should be disaggregated by temporal order (e.g., before and after midterm) or by operation (e.g., lecturing, grading, individual counseling),⁴¹ or both, and if so, what time periods and what operations; (b) how learning takes place over time (e.g., how does a student acquire knowledge? how is it retained over time? how does learning depend on the size and temporal sequence of instructional inputs? how do the inputs interact with one another and with prior outputs over time?); and (c) what fixed inputs are important (e.g., which teacher attributes or student attributes are important?) and how do they interact with one another (e.g., the nature of the interaction between certain teacher attributes and student attributes, or between the method of instruction and student attributes). Such knowledge will make possible a proper and tight specification of the educational production function. This line of research is one in which educational psychologists, rather than economists, can make the greatest contribution.

Second, theoretical work on models of behavior of the actors in the educational production process will be extremely useful. Specifically, one needs to identify possible modes of behavior for each type of actor and to ascertain how the mode of behavior may depend on identifiable attributes, including possibly aptitudes and values, of the type of actor in question. In addition, one needs to investigate how the behavior of the various actors may interact, depending on their respective attributes. One must also attempt to specify alternative processes through which one or more final production plans, "acceptable" to all actors, may be arrived at, in spite of differences and possibly conflicts in the objectives of the various actors. Game-theoretic techniques may be employed to analyze this last question. Theoretical work on behavior enables us to complete the structural equations model of educational production. Only by specifying the complete model can one hope to identify the true technological relationship. It is envisaged that educators, psychologists, sociologists, economists, and game theorists can usefully collaborate on this aspect of the research.

Measurement

The measurement problem has been discussed earlier. New measurements must be developed for variables like noncognitive outputs

⁴¹ This is not unlike the situation in agricultural production, in which the labor input is sometimes disaggregated into plowing, seeding, weeding, harvesting, and threshing inputs.

for which no measurements are currently available. Better and more appropriate measurements must be developed to replace inadequate existing measurements. In addition, in order to be able to use the measurements intelligently, one must know more about the properties of the various measurements, such as their reliability and sensitivity. The principal contribution in this line of research is likely to come from educators, psychologists, sociologists, and statisticians.

Empirical Implementation

First, it appears clear that unless the sample size is small or the range of variation of the variables is small, one would want to experiment with functional forms less restrictive than either the linear or the linear-logarithmic function. Some kinds of flexible polynomials are possible choices.

Second, it appears equally clear, if the theoretical research on the behavior of the actors bears fruit, that a complete system with full specification of all the behavioral relationships (any joint output will be explicitly recognized), as well as the educational production function, should be used whenever the data base is not fully experimental. Only by estimating a complete system can one obtain an estimate of the underlying technological relationship.⁴² The complete system may include unobservable variables if necessary.

Third, simulation may be a useful technique to ascertain the properties of a complete model before data are processed or even available. Simulation also provides a testing ground for untried hypotheses and can be used to evaluate the robustness of model properties.⁴³

Finally, it is obvious that the proposed research will most certainly increase the data requirements. For example, detailed time budgets for the various actors are necessary for the empirical investigation and verification of the technological relationships derived from the theory of learning. Panel data may be necessary for the identification and estimation of the behavioral patterns. Experimental data may be needed to yield information for input-output combinations that are not observed in the natural environment. Finally, personal interview, questionnaire, or survey data, eliciting information on potential rather than actual choices, may also be useful in the determination of the behavioral patterns of individual actors.

As a practical matter, given the lack of measurements for noncognitive outputs and the inadequacy of measurements that relate to the

⁴² One should add that this problem is not unique to educational production function analysis but arises in all types of applied economic studies.

⁴³ See Luecke and McGinn (1975) for an application of simulation in educational production function research.

potential of learning in the home environment, as distinct from a student's ability, attitude, and interest, it may be desirable to concentrate on the study of cognitive achievements of students in higher grades or college (for whom noncognitive outputs are likely to be less important) on more specialized subjects like foreign languages and physical sciences, for which the direct influence of home background is likely to be small. Even for the lower grades, there is evidence that the direct influence of home background is less important in mathematics than in reading comprehension. It may thus be possible by taking advantage of these tendencies to obtain a rather clean set of results. While this strategy has obvious advantages, it also has the obvious drawback that, because of selective retention in the higher grades, one is unlikely to learn much about the educational production of low academic achievers from this type of data base.

REFERENCES

- Adelman, I., & Parti, M. *The determinants of student achievement: A simultaneous equations approach*. Unpublished manuscript, no date. (Available from I. Adelman, Department of Economics, University of Maryland, College Park, Md. 20740.)
- Averch, H. A., Carroll, S. J., Donaldson, T. S., Kiesling, H. J., & Pincus, J. *How effective is schooling? A critical review of research*. Englewood Cliffs, N.J.: Educational Technology Publications, 1974.
- Block, J. H. (Ed.). *Mastery learning: Theory and practice*. New York: Holt, Rinehart & Winston, 1971.
- Bloom, B. S. (Ed.). *Taxonomy of educational objectives, handbook I: The cognitive domain*. New York: McKay, 1956. (a)
- Bloom, B. S. (Ed.). *Taxonomy of educational objectives, handbook II: The affective domain*. New York: McKay, 1956. (b)
- Bloom, B. S. *Stability and change in human characteristics*. New York: Wiley, 1964.
- Bloom, B. S. Time and learning. *American Psychologist*, 1974, **29**, 682-688.
- Boardman, A. E., Davis, O. A., & Sanday, P. R. *A simultaneous equation of the educational process: The Coleman data revisited with emphasis upon achievement*. Paper presented at the Annual Meeting of the American Statistical Association, New York, December 1973.
- Bowles, S. S. Towards an educational production function. In W. L. Hansen (Ed.), *Education, income, and human capital*. New York: Columbia University Press, 1970.
- Bowles, S. S., & Gintis, H. *Schooling in capitalist America*. New York: Basic Books, 1976.
- Bowles, S. S., & Levin, H. M. The determinants of scholastic achievement—A critical appraisal of some recent evidence. *Journal of Human Resources*, 1968, **3**, 3-24. (a)

- Bowles, S. S., & Levin, H. M. More on multi-collinearity and the effectiveness of schools. *Journal of Human Resources*, 1968, **3**, 393-400. (b)
- Brandl, J. E. Comments. In W. L. Hansen (Ed.), *Education, income, and human capital*. New York: Columbia University Press, 1970.
- Brown, B. W., & Sacs, D. H. The production and distribution of cognitive skills within schools. *Journal of Political Economy*, 1975, **83**(3), 571-594.
- Campbell, D. T., & Stanley, J. C. *Experimental and quasi-experimental design for research*. Chicago: Rand-McNally, 1966.
- Carnoy, M., & Levin, H. M. *A systems approach to research for educational development in Venezuela*. Caracas, Venezuela: Ministerio de Education, Dirección de Planeamiento, 1970.
- Cartoll, J. B. A model for school learning. *Teachers College Record*, 1963, **64**, 723-733.
- Cartoll, J. B. *The teaching of French as a foreign language in eight countries*. New York: Halsted, 1975.
- Chenery, H. B. Engineering production functions. *Quarterly Journal of Economics*, 1949, **63**, 507-531.
- Cronbach, L. J., & Snow, R. E. *Aptitudes and instructional methods: A handbook for research on interactions*. New York: Irvington, 1977.
- Goldberger, A. S. *Econometric theory*. New York: Wiley, 1964.
- Griliches, Z. Specification bias in estimates of production functions. *Journal of Farm Economics*, 1957, **39**, 8-20.
- Hanushek, E. A. *Education and race: An analysis of the educational production process*. Lexington, Mass.: Heath, 1972.
- Hanushek, E. A., & Jackson, J. E. *Statistical methods for social scientists*. New York: Academic Press, 1977.
- Henderson, V., Mieszkowski, P., & Sauvageau, V. *Peer group effects and educational production functions*. Ottawa: Economic Council of Canada, 1976.
- Husén, T. (Ed.). *International study of achievement in mathematics: A comparison of twelve countries* (2 vols.). New York: Wiley, 1967.
- Inkeles, A. The international evaluation of educational achievement. *Proceedings of the National Academy of Education*, 1977, **4**, 139-200.
- Jamison, D. T. *Radio education and student repetition in Nicaragua*. Unpublished manuscript, 1977. (Available from World Bank, Development Economics Department, Room D-542, 1818 H Street, N.W., Washington, D.C. 20433.)
- Jamison, D. T., Fletcher, J. D., Suppes, P., & Atkinson, R. C. Cost and performance of computer-assisted instruction for education of disadvantaged children. In J. Froomkin, D. T. Jamison, & R. Radner (Eds.), *Education as an industry*. Cambridge, Mass.: NBER, Ballinger, 1976.
- Jamison, D. T., Suppes, P., & Wells, S. J. The effectiveness of alternative instructional media: A survey. *Review of Educational Research*, 1974, **44**, 1-67.
- Jöreskog, K. G., & Goldberger, A. S. Estimation of a model with multiple indicators and multiple causes of a single latent variable. *Journal of the American Statistical Association*, 1975, **70**, 631-639.
- Jorgenson, D. W., & Lau, L. J. *Duality and technology*. Amsterdam: North-Holland, in press.

- Karweit, N. A reanalysis of the effect of quantity of schooling on achievement. *Sociology of Education*, 1976, **49**, 236-246.
- Kennedy, W. J., & Bancroft, T. A. Model building for prediction in regression based upon repeated significance tests. *Annals of Mathematical Statistics*, 1971, **42**, 1273-1284.
- Klees, S. J. *Instructional technology and its relationship to quality and equality in education in a developing nation: A case study of instructional television in Mexico*. Unpublished doctoral dissertation, Stanford University, 1974.
- Klees, S. J. *Television and other determinants of scholastic achievement in Mexican secondary education*. Unpublished manuscript, 1976. (Available from S. J. Klees, School of Education, Stanford University, Stanford, Calif. 94305.)
- Klees, S. J., & Wells, S. J. *Cost effectiveness and cost-benefit analysis for educational planning and evaluation: Methodology and application to instructional terminology*. Unpublished manuscript, 1977. (Available from S. J. Klees, School of Education, Stanford University, Stanford, Calif. 94305.)
- Leibenstein, H. X-efficiency vs. allocative efficiency. *American Economic Review*, 1966, **56**, 392-415.
- Levin, H. M. A new model of school effectiveness. In *Do teachers make a difference?* Washington, D.C.: U.S. Department of Health, Education, and Welfare, Office of Education, 1970.
- Levin, H. M. Measuring efficiency in educational production. *Public Finance Quarterly*, 1974, **2**, 3-24.
- Levin, H. M. Cost-effectiveness analysis in evaluation research. In M. Guttenberg & E. Struening (Eds.), *Handbook of evaluation research* (Vol. 2). Beverly Hills, Calif.: Sage, 1975.
- Levin, H. M. Concepts of economic efficiency and educational production. In J. Froomkin, D. T. Jamison, & R. Radner (Eds.), *Education as an industry*. Cambridge, Mass.: NBER, Ballinger, 1976.
- Levin, H. M., & Snow, R. E. The emerging intersection of economics and psychology in educational research. In J. E. Bruno (Ed.), *Emerging issues in education: Policy implications for the schools*. Lexington, Mass.: Lexington Books, 1972.
- Lewis, E. G., & Massad, C. E. *The teaching of English as a foreign language in ten countries*. New York: Halsted, 1975.
- Luecke, D. F., & McGinn, N. F. Regression analyses and educational production functions: Can they be trusted? *Harvard Educational Review*, 1975, **45**, 325-350.
- Mayo, J., Hornik, R., & McAnany, E. *Educational reform with television: The El Salvador experience*. Stanford, Calif.: Stanford University Press, 1976.
- Michelson, S. *The existentialist reality of educational production functions (Their existence has preceded their essence)*. Washington, D.C.: U.S. Department of Health, Education, and Welfare, Office of Education, 1970. (Monograph)
- Murnane, R. *The impact of school resources on the learning of inner city children*. Unpublished doctoral dissertation, Yale University, 1974.
- Murnane, R. *The impact of school resources on the learning of inner city children*. Cambridge, Mass.: Ballinger, 1975.
- Postlethwaite, T. N. *A selection from the overall findings of the I.E.A. study in science, reading comprehension, literature, French as a foreign language, and civic*

- education. Paper presented at the Conference on Educational Achievement, Harvard University, 1973.
- Rivlin, A. M., & Timpane, P. M. (Eds.). *Planned variation in education: Should we give up or try harder?* Washington, D.C.: Brookings Institution, 1975.
- Rosenshine, B. *Teaching behaviours and student achievement*. Slough, England: National Foundation for Educational Research on England and Wales, 1971.
- Simmons, J., & Alexander, L. The determinants of social achievement in developing countries: A review of the research. In *Economic Development and Cultural Change*, in press.
- Summers, A. A., & Wolfe, B. L. Which school resources help learning? Efficiency and equity in Philadelphia public schools. *Federal Reserve Bank of Philadelphia Business Review*, 1975, 4-28.
- Theil, H. Specification errors and the estimation of economic relationships. *Revue de l'Institut International de Statistique*, 1957, 25, 41-51.
- Thorndike, R. L. *Reading comprehension education in fifteen countries: An empirical study*. New York: Halsted, 1973.
- Walker, D. A. *The IEA six subject survey: An empirical study of education in twenty-one countries*. New York: Halsted, 1976.
- Wells, S. J. *Technology, efficiency, and educational production*. Unpublished doctoral dissertation, Stanford University, 1973.
- Wells, S. J. *Instructional technology in developing countries: Decision-making processes in education*. New York: Praeger, 1976.
- Wells, S. J., & Jamison, D. T. *The impact of varying levels of computer-assisted instruction on the academic performance of disadvantaged students*. Princeton, N.J.: Educational Testing Service, in press.
- Wiley, D. E. *Another hour, another day: Quantity of schooling, a potent path for policy* (Studies of Educational Processes Rep. 3). Chicago: University of Chicago, School of Education, 1973.
- Wiley, D. E., & Harnischfeger, A. Explosion of a myth: Quantity of schooling and exposure to instruction, major educational vehicles. *Educational Researcher*, 1974, 3, 7-12.

Chapter 3

SCHOOL DISTRICT BEHAVIOR, MARKETS FOR EDUCATIONAL RESOURCES, AND THE IMPLICATIONS FOR PUBLIC POLICY: A SURVEY

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LOCAL public education is one of the largest and most important industries to affect the life of an American citizen. The vast majority of Americans attend local public schools during some part of their lives and virtually everyone either derives benefits from or provides support (directly or indirectly) for the operations of this industry. Public schools are entrusted with the awesome responsibility of educating the youth of this country. We charge these institutions with the responsibility for providing our youth with the relevant cognitive and affective traits that will ultimately be translated into job skills and increased earnings, scientific and technological innovation, economic growth, increased democratic participation, a common core of moral values, the development of a viable cultural heritage, and an improved distribution of opportunities directed at reducing the importance of socioeconomic status in determining an individual's life chances.

Two major factors have stimulated the call for a reassessment of both the goals and the effectiveness of the public school system. One factor has been the raised social consciousness of the 1960s which led to the push for improved equality of opportunity. In the arena of

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education, this stimulus has resulted in judicial and legislative attempts to reform school finance (see Pincus, 1974, and "Future Directions for School Finance Reform," 1974, for discussions). The second major factor has been the taxpayer revolt. This revolt has been a response to the relative growth of the public sector, the rising costs of government service, and the economic crunch of general inflation and rising unemployment during the early 1970s. Furthermore, the taxpayer revolt has largely been focused at the local level because of the greater proximity of local decision-makers and the accompanying ease with which local taxpayers can vent their wrath. Combining these elements with some of the alleged (and well-publicized) failures of public education in recent years (Barro, 1970; Carnoy, 1972; Coleman et al., 1966; Levin, 1968a) and the result has been increasing demands by the public for accountability and efficiency in public schools.

The expressed desire for greater equality of educational opportunity and increased effectiveness necessarily involves an increased demand for educational policy research. The purpose of such research is to provide guidelines for policymakers in formulating reform legislation. It is within this context that the powerful analytical tools of the economist have been brought to bear on these issues of allocation and distribution of educational resources. Nevertheless, a complete understanding of all of the related issues requires a multidisciplinary perspective—one which incorporates the political, legal, sociological, and psychological perspectives on education. Therefore, this chapter is but a modest attempt to deal with some of the foregoing policy issues.

This chapter surveys some of the most significant economic contributions to the analysis of resource allocation in public school districts. The ultimate purpose will be to develop and evaluate the implications of the existing literature within a policy context. The importance of this approach is in revealing precisely how these models relate to specific aspects of educational policy and how they might serve as a guide to the formulation of reform measures. To serve the stated purpose of this survey, we focus attention on school-finance reform, which has been the driving force behind much of the literature on resource allocation in public schools. At the center of the debate is the issue of equity in the financing of educational services. This issue involves the determination of methods by which policymakers can equalize the distribution of funds to reduce or eliminate entirely the differences in the quality of educational services attributed to disparities in wealth across local school districts. By

whatever method we reduce the dependence of educational expenditures on wealth, we must also recognize two other factors that affect local school decision-making: (a) the differences in the prices of school inputs and (b) the differences in pupil-need (e.g., as reflected by the proportions of disadvantaged and handicapped pupils in a district).

In the sections outlined below, we discuss and evaluate one possible analytical approach to the development of public policy with respect to these various factors in school-finance reform and, in particular, provide a conceptual and empirical framework which may be useful in making welfare comparisons across school districts. In the first part of this chapter, a conceptual framework for the analysis of resource allocation in public school districts is presented. In the second part, the notion of wealth or fiscal disparity is defined and measured, and the implications for assessing equal educational opportunity are developed. In the third part, the sources and nature of the variations in the cost of educational resources are examined. The final section presents an agenda for future research in this area along with some concluding remarks regarding the policy perspective presented in this chapter.

A CONCEPTUAL FRAMEWORK

Variation in educational expenditures is composed of essentially two elements: (a) variation in the amount (or quality) of educational services purchased and (b) variation in the unit cost of those services. Determination of the demand for, and the unit costs of, educational services may be formally conceptualized within the context of a two-stage decision-making process. Each stage can be associated with one side of the market, that is, supply or demand. It is necessary to separate the decision process into two stages in order to identify the underlying structural relations associated with each side of the market. However, one feature of this decision process that is unique to the government (or collective) enterprise is that formal interaction between supply and demand does not occur in a market as we know it in the private sector. In the private sector, individual consumers, who represent the demand side of the market, interact with independent producers, who represent the supply side of the market, to determine the equilibrium levels of price and quantity. In public education, local school decision-makers determine the costs of supplying educational services but are simultaneously responsible for the determination of the community's demand (as conveyed through the political process)

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for educational services. Hence, local school officials are responsible for making decisions about both supply and demand for educational services.

Supply: Educational Costs and Budget Allocation

The first stage of this decision process involves the determination of the cost of supplying educational services. School decision-makers are assumed to select the combination of school inputs that can be used to produce a given level of (perceived) educational quality at least cost. The solution of this allocation problem will permit decision makers to determine conceptually the relation between educational expenditures per pupil and the level of educational quality (services) that the district could produce holding constant those exogenous factors affecting the supply prices of school inputs and the nature of the educational technology.

The term *educational quality* in this context refers to the perceptions of local school decision-makers regarding the nature of the educational technology and the quality of services derived therefrom. That is, school inputs are weighted in importance according to their apparent contribution to the quality of educational services. As a non-market governmental enterprise, the public school system must operate on the basis of what is credible and visible to the local community (Lindsay, 1976). The assessment of educational quality reflected in the input selections of school officials must appear believable to the citizenry. Conventional wisdom suggests that inputs are a measure of, or proxy for, educational quality, and it is up to decision makers to convince the community that the district's revealed preferences for these various inputs reflect contributions to educational quality.

Formally, the decision problem associated with the first stage may be stated in either of two ways: School officials are assumed to minimize the expenditure necessary to produce a given level of (perceived) educational quality or to maximize the level of educational quality produced from a given budget.¹ Either of these ways of characterizing the first stage will lead to the same basic rules for allocating resources (i.e., selecting the appropriate combination of

¹ For the noneconomist not accustomed to conceptualizing behavior within a maximization framework and for those familiar with the operations of public schools, this formulation of school district behavior may seem rather unrealistic. This conceptualization does not imply that maximizing behavior is conscious or even deliberate but rather suggests that school decision-makers behave *as if* they did maximize. As Samuelson (1972) expresses it, "The very name of my subject, economics, suggests economizing or maximizing" (p. 249). Samuelson goes on to suggest: "In connection with the role of maximum principles in natural science, the plumb-line trajectory of a falling apple

school inputs). The solution to the budget-allocation problem involves the formal specification of a set of behavioral-input demand equations which may be written as follows:

$$(1) \quad I = D_I(P, N, S, E),$$

where

- I = a vector of the quantity of school inputs employed,
- $D_I(\cdot)$ = the vector of demand functions for school inputs,
- P = the vector of exogenous factors affecting school input prices,
- N = the vector of pupil characteristics reflecting educational need,
- S = a variable reflecting the scale of district operation (e.g., total enrollment), and
- E = the per-pupil educational budget of the school district.

The solution to the expenditure minimization problem may be formally expressed as the cost function,

$$(2) \quad E = C(Q, P, N, S),$$

where Q is the (perceived) quality of educational services. The specific properties of Equations 1 and 2 will depend upon the properties of the perceived educational technology (i.e., the perceived relationship between educational quality and the school and nonschool inputs) and the properties of the input supply functions (see Chambers, 1975, Appendix A, for an example).

Given the specifications of Equations 1 and 2, one can see that there are two kinds of factors that influence the variation in the cost of educational services: first, those factors (P) that affect the *supply*, and therefore the prices, of school inputs and, second, those factors (N and S) that affect the *technology* (i.e., the perceived relationship between school outcomes and school inputs) of the educational production process.

and the elliptical orbit of a wandering planet may be capable of being described by the optimizing solution for a specifiable programming problem. But no one will be tempted to . . . attribute to the apple or the planet freedom of choice and consciously deliberative minimizing. . . . Often the physicist gets a better, a more economic, description of nature if he is able to formulate the observed laws by a maximum principle. Often the economist is able to get a better, more economical, description of economic behavior from the same device" (pp. 250-251).

*Demand: Allocating Community Resources
and Budget Determination*

The second stage of the decision process focuses on the determination of the demand for educational quality by the local community. Given the factors affecting the cost of educational services (i.e., those outlined in Equation 2 above) and the financial and demographic characteristics of the community, local school decision-makers select the level (or quality) of educational services based on their perception of the willingness of the local community to bear (at the margin) increased school tax burdens per family (a negative good) to obtain greater (perceived) educational quality (a positive good). The amount of educational services purchased (i.e., demanded) by the local community will depend on the *relative cost* of educational services (i.e., the cost of educational services relative to the prices of all other consumer goods and services), the overall *fiscal capacity* of the school district (i.e., local fiscal capacity along with the level of any lump-sum intergovernmental grants-in-aid from state and federal sources), and the *taste* (or preferences) for educational services of the local constituency. *Relative cost* in this context includes not only the factors reflected in the cost function, Equation 2, but also the effective local tax price of educational spending as influenced by any matching grant provisions attached to intergovernmental aid formulas.²

The demand function for educational quality may be written:

$$(3) \quad Q = D_Q(P_Q, F, G, T)$$

where

$D_Q(\cdot)$ = the demand function for educational quality,

P_Q = the factors reflecting the *relative cost* of educational services including *supply* (P) and *technology* (N and S) factors, and *matching grant provisions* in intergovernmental aid formulas,

F = a vector of variables reflecting *local fiscal capacity*,

G = the amount of lump-sum intergovernmental grants-in-aid provided to the local school district,

T = a vector of factors affecting the taste for educational services.

² The local tax price equals the cost of an additional dollar of educational spending to the local community. If the state matched the local district dollar for dollar of local spending, then the matching rate would be .5 and would imply that the local tax price of one additional dollar of educational spending is 50 cents.

Presumably, holding all else equal, the higher the relative cost of educational services, the less will be purchased (i.e., the demand curve for educational quality is negatively sloped), and communities with greater fiscal capacity will purchase greater amounts of educational quality.

Because of the obvious problems associated with measuring educational quality, direct observation of Equation 3 will be extremely difficult. To make inferences about the properties of Equation 3, one may estimate the demand for educational expenditure, which is derived by substituting Equation 3 into Equation 2. This may be expressed as

$$(4) \quad E = D_E(P_Q, F, G, T)$$

where D_E is the demand function for educational expenditure. We can infer the properties of Equation 4 from the hypothesized properties of the cost function (Equation 2) and the quality demand function (Equation 3).

The sets of equations contained in either Equations 1 and 4 or Equations 2 and 3 provide a conceptual framework that may serve as a guide to the organization and analysis of the data necessary to describe the behavior of local public school districts. It is within the context of this conceptual framework that we now undertake to discuss the various aspects of school-finance reform.

WEALTH DISPARITIES AND EQUAL EDUCATIONAL OPPORTUNITY

It has been generally observed that considerable variation in per-pupil educational expenditures exists both across states and across individual school districts within states. Table 1 exhibits the wide variation in per-pupil expenditures that existed across states for the 1974-75 school year. Expenditures varied from a low of \$834 per pupil in Mississippi to a high of \$2,005 per pupil in New York State. This represents a relative range of variation just in excess of 2.4 ($= 2,005/834$). Table 2 gives an indication of the expenditure variation that existed in 1969-70 within each of the 50 states. The median range of variation within states reveals that the highest spending districts spend approximately 3.6 times the amount that the lowest spending districts spend on education. Thus, the range of variation of nominal differences in expenditures is greater within states than across states. As revealed by the conceptual framework, the variation reflected in Tables 1 and 2 may in part be explained by cost differentials and in part by variation in the demand for educational quality.

TABLE 1
Variation in Per-pupil Educational Expenditures
Across States, 1974-75

State	Average expenditure per ADA	Ratio to U.S. average	Rank in U.S.
Alabama	871	.69	49
Alaska	1,624	1.29	3
Arizona	1,176	.94	26
Arkansas	896	.71	47
California	1,210	.96	22
Colorado	1,188	.95	25
Connecticut	1,507	1.20	6
Delaware	1,485	1.18	8
District of Columbia	1,814	1.45	2
Florida	1,147	.91	27
Georgia	1,000	.80	38
Hawaii	1,384	1.10	13
Idaho	910	.73	45
Illinois	1,376	1.10	14
Indiana	1,074	.86	32
Iowa	1,240	.99	21
Kansas	1,444	1.15	10
Kentucky	864	.69	50
Louisiana	1,376	1.10	15
Maine	1,007	.80	39
Maryland	1,369	1.09	16
Massachusetts	1,356	1.08	17
Michigan	1,547	1.23	5
Minnesota	1,423	1.13	12
Mississippi	834	.66	51
Missouri	1,078	.86	33
Montana	1,269	1.01	20
Nebraska	1,211	.96	23
Nevada	1,101	.88	29
New Hampshire	1,095	.87	30
New Jersey	1,565	1.25	4
New Mexico	1,052	.84	34
New York	2,005	1.60	1
North Carolina	1,052	.84	35
North Dakota	1,032	.82	37

(Table 1—Continued)

State	Average expenditure per ADA	Ratio to U.S. average	Rank in U.S.
Ohio	1,144	.91	28
Oklahoma	1,009	.80	40
Oregon	1,425	1.14	11
Pennsylvania	1,446	1.15	9
Rhode Island	1,493	1.19	7
South Carolina	984	.78	41
South Dakota	973	.78	42
Tennessee	903	.72	46
Texas	894	.71	48
Utah	942	.75	43
Vermont	1,095	.87	31
Virginia	1,054	.84	36
Washington	1,199	.96	24
West Virginia	910	.73	44
Wisconsin	1,323	1.05	18
Wyoming	1,322	1.05	19
UNITED STATES	1,255	1.00	-

Note. Data on average expenditure per ADA are from *The Standard Educational Almanac*, 1976-77, Marquis Academic Media, Chicago (1976), p. 304, column 8.

It has been alleged that wealthy school districts outbid poorer districts in the market for educational resources and are therefore able to provide "better quality" educational services. Two problems of measurement and definition arise in this context. The first problem involves defining what is meant by quality. One might ask whether more school inputs necessarily imply better quality educational services. The second problem concerns the definition and measurement of the concept of wealth disparity or fiscal capacity.

It is essential that we make some judgments regarding each of these issues for the purpose of guiding policymakers. It is only with some sort of judgment about these issues that we will be prepared to arrive at some practical agreement as to how to define equal educational opportunity. The following discussion proposes one possible approach, along with the corresponding rationale, to resolving these issues. The proposed approach should be regarded as a practical rather than a precise solution to these problems of definition and measurement. This is because the state of the art in educational

TABLE 2

Elementary and Secondary Public School Expenditures per Pupil,
by State, 1969-70 School Year (the Ratio of Expenditures in
Each Spending Category to Expenditures in the Low-spending
District for Each State Is Shown in Parentheses)

State	Low-spending district	Median district	Ninetieth percentile district	High-spending district
(1)	(2)	(3)	(4)	(5)
Alabama	294	407 (1.38)	473 (1.61)	580 (1.97)
Alaska	480	994 (2.07)	1,254 (2.61)	1,810 (3.77)
Arizona	410	713 (1.74)	991 (2.42)	2,900 (7.07)
Arkansas	294	407 (1.38)	512 (1.74)	1,005 (3.42)
California	402	747 (1.86)	918 (2.28)	3,187 (7.93)
Colorado	444	694 (1.56)	853 (1.92)	2,801 (6.31)
Connecticut	499	772 (1.55)	1,002 (2.01)	1,311 (2.63)
Delaware	633	741 (1.17)	1,001 (1.71)	1,081 (1.71)
Florida	582	722 (1.24)	824 (1.42)	1,036 (1.78)
Georgia	364	516 (1.42)	706 (1.94)	735 (2.02)
Hawaii	851	486 (1.57)	851 (1.00)	851 (1.00)
Idaho	483	664 (1.37)	904 (1.87)	3,172 (6.57)
Illinois	390	892 (2.29)	1,129 (2.89)	2,295 (5.88)
Indiana	373	619 (1.66)	729 (1.95)	961 (2.58)
Iowa	591	752 (1.27)	912 (1.54)	1,166 (1.97)
Kansas	489	646 (1.32)	798 (1.63)	1,572 (3.21)
Kentucky	344	462 (1.34)	576 (1.67)	885 (2.57)
Louisiana	499	655 (1.31)	730 (1.46)	922 (1.85)
Maine	215	551 (2.56)	660 (3.07)	1,966 (9.14)
Maryland	634	795 (1.25)	1,037 (1.64)	1,036 (1.63)
Massachusetts	454	732 (1.61)	963 (2.12)	4,243 (9.35)
Michigan	409	734 (1.79)	888 (2.17)	1,275 (3.12)
Minnesota	373	650 (1.74)	777 (2.08)	1,492 (4.00)
Mississippi	321	453 (1.41)	541 (1.69)	825 (2.57)
Missouri	213	667 (3.13)	808 (3.79)	1,929 (9.06)
Montana	467	900 (1.93)	1,358 (2.91)	8,515 (18.23)
Nebraska	274	621 (2.27)	786 (2.87)	3,417 (12.47)
Nevada	747	838 (1.12)	929 (1.25)	1,678 (2.25)
New Hampshire	280	594 (2.12)	739 (2.64)	1,356 (4.84)
New Jersey	484	772 (1.60)	1,009 (2.08)	2,876 (5.94)

(Table 2—Continued)

State	Low-spending district	Median district	Ninetieth percentile district	High-spending district
(1)	(2)	(3)	(4)	(5)
New Mexico	477	520 (1.09)	645 (1.35)	1,183 (2.48)
New York	633	1,077 (1.70)	1,193 (1.88)	7,241 (11.44)
North Carolina	467	590 (1.26)	675 (1.45)	732 (1.57)
North Dakota	327	649 (1.98)	776 (2.37)	1,842 (5.63)
Ohio	412	648 (1.57)	881 (2.14)	1,684 (4.09)
Oklahoma	309	557 (1.80)	662 (2.14)	2,565 (8.30)
Oregon	431	798 (1.85)	914 (2.12)	4,941 (11.46)
Pennsylvania	535	845 (1.58)	1,102 (2.06)	4,230 (7.91)
Rhode Island	531	736 (1.39)	1,045 (1.97)	1,206 (2.27)
South Carolina	397	511 (1.29)	562 (1.42)	610 (1.54)
South Dakota	175	607 (3.47)	750 (4.29)	6,012 (34.35)
Tennessee	315	491 (1.56)	629 (2.00)	744 (2.46)
Texas	197	540 (2.74)	668 (3.39)	11,096 (56.32)
Utah	533	568 (1.07)	630 (1.18)	1,514 (2.84)
Vermont	357	687 (1.92)	905 (2.54)	1,417 (4.25)
Virginia	441	606 (1.37)	776 (1.76)	1,159 (2.63)
Washington	433	831 (1.92)	981 (2.27)	3,993 (9.22)
West Virginia	502	601 (1.20)	706 (1.41)	721 (1.44)
Wisconsin	408	747 (1.83)	849 (2.08)	1,391 (3.41)
Wyoming	617	706 (1.14)	1,146 (1.86)	14,554 (23.59)

Note. Reischauer and Hartman (1973), Table 4-4, p. 66.

research is not so far advanced as to offer any precise solutions and because, in view of the immediacy of judicial mandates and the pressures for legislative action on school-finance reform, there is not time to await the advancement of research to such a point where more precise solutions are available.

Measuring Educational Quality

Ideally, one would devise some universally accepted concept of educational quality that would allow for welfare comparisons across school districts. However, the determination of such an index of educational quality necessarily implies that some prior decisions have been made not only with regard to the relevant set of outcomes (e.g., the set of skills, abilities, and personal traits we expect schools to

transmit to pupils) but also with regard to the relative importance that should be assigned to each outcome. Few of the multiple outcomes attributed to the educational process lend themselves to any sort of precise measurement. This fact is particularly true of the qualitative outcomes such as attitudinal and behavioral traits of pupils. Even for those outcomes, such as the cognitive skills, for which measures exist, the questions of test validity and reliability are of considerable concern to those evaluating the results (Averch, Carroll, Donaldson, Kiesling, & Pincus, 1974; Coleman & Karweit, 1970). Furthermore, some of the most important inputs (e.g., teacher characteristics and attitudes) are extremely difficult to quantify with accuracy.

Even if a set of measurable educational outcomes were identified, one would have to set about the task of determining the technology by which the outcomes are produced. Specifying the technology involves determining the relevant inputs, the nature of interactions among the outputs and the inputs, and the relationships between outputs and inputs, as well as the separation of the school from nonschool effects. In view of the complex nature of human behavior that characterizes the educational process, the specification of an educational technology becomes, at the very least, a formidable task indeed (Averch et al., 1974; Bowles, 1970; Levin, 1974). Given the primitive state of the art revealed in current studies of the educational production process and the potential for conflict involved in the process of selecting and weighting the various components of a quality index, it is only too obvious that educational quality and technology cannot at this time be measured or assessed in any precise manner.

A Behavioral Approach to Assessing Differences in School Quality

With all of these problems of evaluation and measurement in mind, one might employ a concept analogous to consumer sovereignty to resolve what we mean by educational quality. The concept of consumer sovereignty implies that the wants of the society are expressed in the market. Consumers as a collective force in the market determine the pattern of economic activity. If consumers do not desire a particular good or service, or are unwilling to purchase it at the offered price, that good or service will go unsold.

Applied to the market for school inputs, this analysis suggests that we rely upon the judgments, as revealed through market behavior, of local school decision-makers regarding which school inputs do or do not contribute to educational quality. For the purpose of separating the valued from the nonvalued school inputs in assessing wealth

disparities or educational cost differentials, why should researchers or educational policymakers, who are in general a considerable distance from the ongoing process of education, make arbitrary judgments as to what does or does not constitute school quality? In the first place, local decision-makers (i.e., school boards and school administrators) are closest to the actual production process and are perhaps more likely to be able to perceive and assess existing input-output relationships.³ Second, it is the local decision-makers who are more directly responsible for reflecting and representing the perceptions and preferences of local constituencies with regard to educational priorities.

Based on these considerations, one approach to assessing differences in educational quality would be to rely on the perceptions of those who have been given the responsibility by local citizens to make educational decisions. If one accepts this premise, then a market test can be devised that will reveal which school inputs are perceived by local decision-makers as contributing to educational quality. The use of such a methodology relieves the researcher or policymaker from having to make further judgments regarding this issue.

The empirical methodology involves the determination of which educational inputs are *endogenous* (i.e., a matter of choice) to local school district decision-makers. For example, for which teacher or administrator characteristics are school officials willing to pay a price on the market, and, more importantly, for which of these characteristics does the level of employment respond systematically to changes in school input prices and school budgets? If school districts do not desire to purchase a particular teacher characteristic (i.e., because the characteristic is not perceived as contributing to educational quality), then that characteristic will not bring forth a price (either explicitly or implicitly) in the market for teachers. Furthermore, for those characteristics that are (are not) desired by school districts, the level of employment of that characteristic will (will not) respond systematically to price and budget changes and an *implicit* market price will (will not) be revealed.

To place this methodology within the conceptual framework outlined previously, the implementation of this approach involves empirical estimation of Equations 1 and 4: the input demand equations

³ The behavioral approach might very well be useful in aiding researchers in the selection of the set of inputs that should be included in educational production-function analysis. In particular, it would be of interest to subject to empirical analysis the hypothesis that those inputs valued by local school decision-makers in the market are in fact productive inputs as revealed within the context of the production-function studies.

$D_I(\cdot)$ and the expenditure demand equation $D_E(\cdot)$.⁴ The endogenous variables would be designated as those variables which exhibited systematic variation (i.e., as determined by statistical significance of the parameters of the input and expenditure demand equations) in response to variation in input prices, pupil need, scale of district operations, and the educational budget.

Empirical evidence on demand for school inputs. With this approach in mind, it would be revealing to examine the empirical evidence on how school districts allocate their budgets. Specifically, which inputs are preferred in the market for educational resources and how much is spent on each at the margin? The studies discussed below examine only a limited set of inputs. More comprehensive studies including a larger, more refined set of inputs will be necessary before the feasibility and reasonableness of the behavioral approach can be fully evaluated.⁵

It is rather remarkable that the studies (Alexander, 1974; Barro & Carroll, 1975; Carroll, 1976; Chambers, in press; Ehrenberg, 1973) that have been done reveal relatively similar results.⁶ For this reason we shall summarize the basic conclusions of all of these studies simultaneously. Although the degree of variation among the estimates varies with the particular input,⁷ the orders of magnitude of the estimated parameters are the same.

The results of these budget-allocation studies generally reveal the following patterns.

1. *Both budget and price elasticities for teachers tend to be less than one in absolute value.* That is, the demand for teachers tends to be relatively insensitive to changes in the prices of school inputs and the levels of

⁴ It is shown in Chambers (1975, App. D) that, because of the nature of the budget determination and allocation process, the budget (or expenditure level) included in the input demand equations will be correlated with the error term necessitating a simultaneous-equations estimation technique (e.g., two-stage least squares) for the input demand equations.

⁵ Much more work will be necessary to analyze the demand for teacher and administrator attributes (e.g., verbal ability, college quality, field of study, and previous administrative experience). Much of the data could be gathered along with the personnel information currently collected in many states by the departments of education.

⁶ Ehrenberg's study focuses on the demand for various categories of public employees including, for example, police, fire, and sanitation as well as education.

⁷ Budget and price elasticities for some inputs were relatively stable across studies, while those elasticities for other inputs varied somewhat more. Demand for different categories of professionals (for teachers—both elementary and secondary—and for educational specialists and administrators) tends to show rather similar results across studies. Demand for certain teacher attributes (such as experience and training) and for expenditure on such things as attendance services, health services, and transportation services tends to be relatively unstable and was not explained very well by the models tested. See, for example, Carroll (1976).

educational budgets. This implies relatively small increases in class size in response to increases in teacher costs. One implication of the observed price inelasticity is the relatively greater potential power of teachers' unions to raise salaries with minimal threat of disemployment.⁸ There is evidence to suggest that unionization among teachers is associated with salary differentials on the order of 10–15%, which is similar in magnitude to the estimated effects of unionization in other areas of the public and private sectors.⁹ Moreover, the evidence suggests that nonbargaining districts located in areas that are substantially unionized tend to match reasonably closely the negotiated wage increases for teachers employed in bargaining districts (i.e., the "threat effects" of unionization appear to be relatively strong).

2. *The demand for secondary school teachers tends to be more price-elastic than that for elementary school teachers.* This implies that high-school class sizes will tend to rise much faster than elementary class sizes in response to increases in teacher costs. One might attribute this difference in price elasticities to the probable difference in the nature of the perceived educational technologies between elementary and high school education. Variations in high-school class sizes may not have as significant an impact on the perceived quality of educational services as would a similar variation in elementary-school class sizes. Therefore, one would expect that a change in the price of teachers' services would tend to elicit a relatively greater response in the demand for high school teachers than in the demand for elementary school teachers.

3. *Budget elasticities of demand for educational specialists and administrators and for instructional materials tend to be greater than the budget elasticities of the demand for teachers.* At the margin, budget allocations to employ additional teachers are smaller than the average shares of budgets spent on teachers, while just the opposite is true for the demand for other educational professionals. For example, Carroll (1976) finds that "other professionals account for about 10 percent of districts' total budgets, but something like 20 to 30 percent of an

⁸ To the extent that tenure and other such restrictions (see Chambers, 1975, chap. 11) characterize discharge policies of public school districts, the disemployment effects will primarily take the form of failure to replace all of the staff members who leave of their own accord. The impact of the disemployment effects on current members of the teachers union is therefore to worsen their working condition by increasing class sizes rather than to pose a threat of unemployment. However, given the recent trend toward declining enrollments, this threat of disemployment may become more important.

⁹ For evidence of the 10–15% wage differentials associated with teacher bargaining, see Chambers (1976, 1977). See Ashenfelter (1971) and Ehrenberg and Goldstein (1975) for studies of public sector bargaining and see Lewis (1963) for the classic study of bargaining in the private sector.

increase in a district's budget would go to increased expenditures for other professionals" (p. 325). This suggests that, once having formed the foundation of their educational programs through the employment of classroom teachers, school officials begin to allocate more and more of their budgets, at the margin, to auxiliary educational personnel.

4. *Only a relatively small portion (less than 11%) of marginal increases in school district budgets are allocated to increasing the level of the teachers' salary schedule.*¹⁰ This result disputes the claim by some (e.g., Moynihan, 1972, p. 75) that increased educational budgets of the poor districts will be used simply to enrich teachers. However, it is not at all clear that one should be consoled by the evidence of the small marginal budget allocations to teachers' salaries. Given the conceptual framework outlined previously, it is evident that the relation between school budgets and teachers' salaries is indirect. Specifically, increased budgets have the effect of increasing the demand for teacher quality (as measured not only by teacher experience and education, but also by such traits as verbal proficiency and other ability traits not explicitly recognized in teachers' salary schedules). The increase in the demand for teacher quality leads to an increase in the salaries necessary to attract these better qualified teachers to the district. In order to recruit higher quality teachers at the margin, districts have to pay higher salaries, *ceteris paribus*. Of course, in the short run, teachers already employed by the district receive higher rewards used to attract, and to allow district officials to select from, a higher quality pool of teachers. Clearly, more empirical investigation needs to be carried out in order to determine the degree to which this conceptual framework actually characterizes the behavior of school decision-makers.¹¹ Nevertheless, there is evidence (Antos & Rosen, 1975;

¹⁰ Increasing the level of the teachers' salary schedule refers to increases in the starting salaries or the increments paid for additional years of experience or schooling, holding constant the average experience and education of the teachers.

¹¹ Owen (1972) attempts to analyze the demand for teacher quality using verbal ability of the teacher as his measure of quality. However, Owen's model is plagued by rather significant deficiencies which make his conclusions difficult to interpret. In particular, he fails to specify the appropriate demand function for teacher quality, in part, because he fails to formulate explicitly the model of budget determination and allocation for the school district. Had he carried out this exercise, he would have arrived at a different estimating equation. Second, Owen ignores the possibility of substitution effects between teacher quality and the quantity of teachers and other school inputs by assuming that the salary budget is essentially fixed along with the numbers of teachers to be hired. He bases his formulation on the Carlsson and Robinson (1969) model. All of these problems make his conclusions difficult to interpret in the context of a more complete model.

Levin, 1968b) that "better quality" teachers are attracted by, and are usually employed in, districts paying higher salaries.

The fact that these budget-allocation studies are predominantly cross-sectional raises an important issue. Would the poor districts act like rich districts if suddenly given the necessary funding? In the cross-section studies, we are attempting to infer the response of any given district to a budget increase by examining the differences in behavior, *ceteris paribus*, of two districts at a point in time with a designated difference in their budgets. Barro and Carroll (1975) attempt to answer this criticism by using a discretionary budget model that focuses on the analysis of changes in budgets from one year to the next across districts. As they point out,

While a two-year data base obviously cannot support a true time series analysis, it does permit us to determine whether year-to-year changes in district outlays are consistent with the marginal behavior implied by the cross-sectional results. (p. 62)

In a summary of their findings, Barro and Carroll conclude:

Mutually supporting findings from the cross-sectional regression equations for both school years,¹² the discretionary budget analysis, and Alexander's California study provide a reasonable basis for believing that the cross-sectional model accurately represents the effects of changes in the school district budget on expenditure components, teacher-pupil ratio, and staff-pupil ratio. (p. xi)

There is perhaps a more serious problem arising from the cross-sectional nature of the model and from the fact that the focus of the analysis is exclusively on the individual school district rather than on the market for teachers. The model and empirical results continue to apply only as long as each district is taken to respond in isolation from the responses of other districts. Much the same problem arises in the conventional microeconomic analysis of the demand for labor by a firm operating in a competitive labor market. For example, what happens to the demand for labor of the individual firm when, say, the price of output changes? To evaluate the response, it is necessary to recognize that all other firms will simultaneously change their behavior in response to a change in the price of output and will therefore affect the market demand for, and hence the equilibrium price of, labor.

If, as some expect, school-finance reform involves a leveling up rather than a redistribution of expenditures, the market for teachers

¹² Barro and Carroll ran separate regressions for both 1968-69 and 1969-70 for the sample of Michigan school districts.

is likely to expand since poorer districts will be receiving additional funds with no change in allocations to wealthier districts (or at least the increased allocations to the poorer districts will exceed those taken from the rich).¹³ As the market expands, the equilibrium wages of teachers may increase. Therefore, in order to determine the allocation of district budgets to increased teachers' salaries as opposed to teacher-pupil ratios or other school inputs, it would be necessary to have estimates of the elasticity of the supply of teachers to the market in which the particular districts are located.

There are two mitigating factors to consider. First, if the long-run supply of teachers is perfectly elastic, then the equilibrium price of teachers will be unaffected by the expanding market and our cross-sectional results might still hold true. Second, given the surplus that appears to characterize the current market for teachers, it may take considerable expansion for the market to return to equilibrium, and hence the supply of teachers, over the relevant range, would be, for all intents and purposes, perfectly elastic. Once again, in order to resolve this issue, further investigation of the markets for teachers will be necessary, and, in particular, such investigations should focus not only on individual districts but also on the entire market for teachers in which these districts are located (see Zabalza, 1976).

The behavioral approach applied to outputs. Although it is more difficult because of the measurement problems discussed above, one might consider applying the behavioral approach of assessing school quality to the demand for school outputs. However, because of the measurement problems, it would of necessity be a somewhat more limited approach.

Brown and Saks (1975) developed a model of school district behavior focusing on the allocation of a fixed set of inputs to "achieve the desired distribution of student scores or outputs" (p. 574). They were really attempting to answer the question "Do school inputs matter (in producing achievement)?" Their contributions to the literature lie in their recognition that both the average level and the distribution of student performance were important, and in their revelation of the explicit interaction between educational technology and tastes for educational outcomes. Their empirical results demonstrated not only that certain school inputs count, but also, at least for certain kinds of districts, that both the mean and the variance (the

¹³ Leveling up involves providing extra funds for relatively poor districts without taking away any aid from the wealthy districts. Whether redistribution of existing funds, leveling up, or some combination of the two is used to resolve the problems posed by school finance reform will depend upon the effective redistribution of the tax burden relative to the benefits received by the various political constituencies interested in educational policy.

distribution) of achievement were regarded as outcomes of the educational process. They conclude:

To answer those questions [about the relative marginal products of school inputs] with nonexperimental data, it will be necessary to understand the nature of the schools' objective functions. It is only by understanding those objectives or welfare functions in different kinds of schools that any progress can be made in unraveling the important empirical questions about the marginal productivity and distributional biases of inputs. In the generally available data, we observe only the interactions of technology and tastes. (p. 593)

Their conclusions clearly imply that substantial benefit could result from research that integrates the models of resource allocation in public school districts with models of the educational production process.

*Measuring Local Fiscal Capacity:
A Behavioral Approach*

A second issue related to the evaluation of equal educational opportunity involves the measurement of the fiscal capacity or the ability of the local school district to purchase educational services. Traditionally, local fiscal capacity has been measured by the local property tax base (a source that provides by far the largest portion of local school taxes in the United States). Using property values as the measure of fiscal capacity, courts and legislatures have focused on methods for achieving wealth neutrality, that is, the independence of local educational expenditure from local property value. District power equalizing (DPE) has been perhaps the most prominently proposed alternative to achieve wealth neutrality. DPE, in effect, provides equal dollars for equal effort. Effort is defined in terms of the local tax rate, which is the decision variable for local school districts under the DPE plan. This concept of equal spending for equal effort still leaves some room for local choice in education based on taste but presumably is intended to eliminate any differences in educational spending based on wealth disparities.

One could contest the DPE formulation on two counts. The first count involves the measurement of equal effort. Coons, Clune, and Sugarman (1970) imply that effort is measured by the local property tax rate. Is an equal tax rate necessarily an appropriate measure of effort? There are a number of alternatives. One practical alternative would be to define equal effort as equal ratios of school tax payments to median family income. More sophisticated and perhaps less practical criteria might include defining equal effort in terms of equal absolute, relative, or marginal sacrifice of utility (see Musgrave & Musgrave, 1976, pp. 215-219).

On the second count, Feldstein (1975) has demonstrated that the distribution of educational funds implied by DPE does not satisfy the most recent mandates of the Court (e.g., in *Serrano v. Priest*) that educational spending be independent of the wealth of a school district. Complete wealth neutrality implies that the elasticity of school spending (denoted by E) with respect to wealth (denoted by W) be equal to zero. Using Feldstein's notation, let

$$(5) \quad \alpha = \frac{d(\ln E)}{d(\ln W)}$$

be the total elasticity of school spending with respect to wealth. Feldstein then specifies the following behavioral equation to explain the variation in school spending:

$$(6) \quad \ln E_i = \beta_0 + \beta_1 \ln W_i + \beta_2 \ln P_i + \sum_{j=3}^K \beta_j \ln X_{ji} + \epsilon_i$$

where

P_i = the net price to the local community for one additional dollar of educational spending (i.e., $1 - m_i$ where m_i is the effective matching rate for state aid to local districts), and

X_{ji} = other determinants of school spending (Feldstein includes median family income, state block grants, federal grants, residential property proportion of local tax base, the number of private-school pupils per capita, and the number of public-school pupils per capita).

Using this formulation, the total wealth elasticity of school spending is given by the expression,

$$(7) \quad \frac{d(\ln E_i)}{d(\ln W_i)} = \beta_W + (\beta_P \cdot \gamma_{PW}) = \alpha$$

where

$$\beta_W = \beta_1 + \sum \beta_j \gamma_{X_j W},$$

$\gamma_{X_j W}$ = the elasticity of X_j with respect to W , and

$$\beta_P = \beta_2.$$

The basic DPE formula requires that the net price be proportional to local wealth. This may be formally expressed as¹⁴

$$(8) \quad P_i = kW_i.$$

This DPE formula implies a unitary elasticity of the local net price of education with respect to wealth, i.e., $\gamma_{PW} = 1$. From this formulation of the problem, it can be seen, using Equations 7 and 8, that "DPE would only be completely wealth neutralizing ($\alpha = 0$) in the very special case in which the absolute wealth and price elasticities [of school spending] were equal" (p. 78), with $\gamma_{PW} = 1$, $\alpha = 0$ if and only if $\beta_W = -\beta_P$.

Using data from a sample of school districts in the state of Massachusetts, Feldstein demonstrates that in fact for his sample $\beta_W < -\beta_P$, which implies that DPE would not be wealth equalizing and that in this particular case it would "result instead in an inverse relation between local wealth and local educational spending" (p. 88). One could perhaps quarrel with Feldstein's behavioral equation regarding the precise formulation,¹⁵ but his basic point regarding the implication of the relative wealth and price elasticities for the neutralizing effects of the DPE formula would still stand.

One additional issue that is ignored by the DPE formulation involves whether local property value is the appropriate measure of fiscal capacity in the context of efforts at equalization. One could argue that the relevant measure of fiscal capacity should be based on some combination of factors that affect the relative burden of school taxes across communities. In particular, one approach to assessing alternative measures of fiscal capacity would involve formulating a behavioral model of the determination of school spending (as reflected in Equation 4) and using this model to assess the relative importance of various local fiscal variables in determining the variation in the level of school spending across communities. Most of the

¹⁴ Feldstein (1975) points out that an alternative and more complex form of DPE does provide for k to be a function, $f(t)$, of the tax rate t (i.e., $P_i = f(t_i) \cdot W_i$). The functional relationship between k and t is determined by the state and is intended to be independent of district wealth (see Coons et al., 1970). The district in this case does not face a fixed price, but rather a price that varies with its choice of educational spending, i.e., the choice of the tax rate t . "Although the choice of an $F(t_i)$ function would obviously affect the resulting wealth neutrality, it might not be possible to design an $f(t)$ that achieves complete wealth neutrality" (p. 79, n. 7).

¹⁵ For example, Barro's (1974) formulation of the spending decision model would specify that there was interaction between the matching rate (or local tax price) and the ratio of public school pupils per population. Moreover, a similar interaction exists for the state block grants with pupils per capita.

studies of school spending begin with some variant of the consumer-analogue model or some modified constrained optimization framework reflecting the decisions of local school officials (see Barro, 1974, chap. 2, for an excellent review).

Ladd (1975) develops empirical estimates of a more general measure of fiscal capacity than that implied by property wealth of the community. Her approach is essentially a behavioral approach to assessing differences in fiscal capacity across districts. Ladd defines fiscal capacity as "a measure of the ability of communities to finance education services." She suggests that "two communities will be said to have equal (*different*) fiscal capacity if, in the absence of taste or preference differentials across communities, they can be expected to provide the same (*different*) level(s) of education services" (p. 153).

To measure fiscal capacity, Ladd includes the following fiscal variables in her expenditure model: median family income, the market value of residential property per pupil, and composition of the local property tax base with respect to residential, commercial, and industrial property.¹⁶ The greater the relative amount of residential versus commercial or industrial property, the greater the relative school tax burden on the voting residents of the community. In effect an increase in the proportion of residential property raises the local tax price to residents and reduces the incentives to spend on educational services. In addition, Ladd attempts to account systematically for the possibility of tax shifting by commercial and industrial property owners. The value of residential property is included to capture the permanent income effect on school spending.

Ladd's parameter estimates were very much in line with those of previous studies of school spending (see Barro, 1974, Tables 1 and 2 in chap. 2). She finds, for example, that a one-dollar increase in unrestricted state aid leads to a 50-cent increase in educational spending, while a one-dollar increase in state or federal categorical aid results in approximately a one-dollar increase in spending. Median family income and residential property value were both positive and statistically significant and exhibited elasticities of approximately .4 and .3, respectively. With regard to tax base composition, Ladd's findings indicate that an increase in the proportion of commercial property has a larger impact on a community's willingness to spend

¹⁶ Other variables included in her expenditure model are the local tax share (comparable to Feldstein's local tax price, P), state block grants, federal and state categorical aid, public-school pupils per capita, private-school pupils per capita, proportion of families with income below the poverty level, and proportion of professional, technical, and kindred workers in the population.

than would a similar increase in the proportion of industrial property. Related to this finding, she reports that 79% of the commercial property tax is not shifted to local residents while only 45% of the industrial property tax was not shifted. These results "are consistent with the view that resident voters perceive that industrial property is potentially more mobile than commercial property in response to fiscal differentials across communities" (p. 152).

To calculate her proposed measure of fiscal capacity, Ladd uses the parameter estimates obtained from the behavioral expenditure regression to determine the variation in expenditure that would have occurred across local school districts in response to variations in family income, the value of the residential property, and the composition of the tax base while all of the other determinants of the variation in educational spending are held constant. This measure is regarded as a behavioral measure of fiscal capacity in the sense that it was derived by aggregating the fiscal components (median family income, residential property value, and tax base composition) by weighting each with its regression coefficient which is an empirical reflection of local school district behavior. Ladd then compares her behavioral measure of fiscal capacity with the traditional measure, total property value per pupil, by ranking each district in her sample (communities in the Boston SMSA for the year 1970) according to the respective measures. In 29% of the cases, district rankings differed by 10 or more. Ladd concludes, in a statistical comparison of the two rankings with a set of socioeconomic and tax-composition variables, that relative to her behavioral measure of fiscal capacity, total property wealth overstates capacity in low-income communities, in communities in which there is high incidence of poverty, and in highly industrialized communities (presumably because of tax shifting).

Implications for Educational Policy

The foregoing analysis has some important implications for the recent judicial and legislative efforts at equalization in school finance. In particular, equalization efforts should be directed toward compensating for the factors that affect the relative ability of local communities to provide different amounts of educational services. One fruitful method for assessing differences in relative ability is by analyzing the spending behavior of local decision-makers. This involves separating from other effects the impact of various fiscal variables (e.g., family income or measures of permanent income and the tax base composition with respect to residential, commercial, and industrial property) on educational spending. Simply using property

value may well lead to a distorted view of the differences in fiscal capacity. Ladd's results, for example, imply that the central cities, where there are concentrations of poor families and of industrial property, are likely to be perceived as having greater fiscal capacity using total property value as a measure than when the behavioral measure, which accounts for the effects of other fiscal variables, is used.

Formally, one could employ the same basic framework that was developed in Feldstein's (1975) paper. Rather than focusing on (property) wealth neutrality, one could employ the concept of fiscal neutrality as measured by Ladd, for example. Let

$$(9) \quad \alpha_F = \frac{d(\ln E)}{d(\ln F)}$$

where F is the behavioral measure of fiscal capacity. The degree of fiscal neutrality can then be determined by

$$(10) \quad \alpha_F = \beta_F + \beta_P \cdot \gamma_{PF}$$

where

β_F = the elasticity of expenditures with respect to fiscal capacity, holding the net price of educational services constant,

β_P = the partial elasticity of expenditures with respect to the net price of educational services to the local community, and

γ_{PF} = the elasticity of the net price of educational services with respect to fiscal capacity.

Complete neutrality implies $\gamma_F = 0$ and can be achieved by policy-makers setting $\gamma_{PF} = -\beta_F/\beta_P$, where γ_{PF} is incorporated into the matching scheme that defines the state-aid formula. In this case the only variation in educational spending would be a result of differences in taste across communities.

None of the existing studies has attempted to employ the type of fiscal capacity measure discussed above for the purpose of assessing the degree of equalization. However, this author (Chambers, 1978) has attempted to assess equalization with respect to family income differences across school districts. To illustrate the behavioral approach, we shall use the results of this previous study to examine the extent of difference in the levels of services of various school inputs (the behavioral measure of school quality) employed across local school districts.

Table 3 presents the empirical estimates of the differences in school spending per pupil, the salaries of school personnel, and the demand for the quantity and quality of teachers' services attributed to differences in the levels of community income (in column 2) and the state and federal grants-in-aid (in column 3). The estimates are based on a regression analysis of resource allocation in a small sample of California elementary-school districts for the 1970-71 school year. For the purpose of this example, the difference between high- and low-income districts is set at \$4,000 per household (approximately equal to two standard deviations for the sample of elementary districts). The empirical results indicate that, other things being equal, districts with higher levels of income per household or larger grants per pupil will tend to spend more on educational services, pay higher

TABLE 3

The Differentials in Educational Expenditures per Pupil, Salaries of School Personnel, and Input Demand Between Two Communities with an Income Differential of \$4,000 per Household^a

Dependent variables (1)	Elementary school districts		
	<i>Differentials due to:</i>		
	Difference in community income (2)	Difference in grants-in-aid per pupil (3)	Net difference (2) + (3) = (4)
Expenditure per pupil	252	-60	192
Starting teacher's salary	230	-45	185
Salary increase for teacher's experience	23	-5	18
Average principal's salary	865	-168	697
Average superintendent's salary	581	-113	468
Average class size	-1.58	.30	-1.28
Average years of teacher's experience	.85	-.17	.68
Average graduate credit hours per teacher	4.25	-.83	3.42

Note. Data are from Chambers (1978).

^a Empirical estimates indicate that for each additional \$1,000 of income per household, the average elementary district gives up \$18.02 in state and federal grants per pupil. The \$4,000 income differential hypothesized above leads to a reduction in grants per pupil of \$72.08 ($= 4 \times 18.02$) for this sample of elementary districts.

salaries to school personnel, and employ greater quantities of school inputs per pupil.

Because of the manner in which state, and to some extent federal, grants are distributed, there is an inverse relationship between the level of community income and grants-in-aid across school districts: Higher income communities generally receive smaller per-pupil grants.¹⁷ One of the objectives of providing school districts with state and federal grants is to equalize educational opportunities across districts by compensating for the existing disparities in fiscal capacity that would otherwise lead to differences in the quality of educational services supplied to children from different socioeconomic backgrounds. The estimates indicate that for each \$1,000 of community income per household, the average elementary district gives up \$18.02 in grants-in-aid per pupil. If the net result of this trade-off between income and grants-in-aid leads to an increase (decrease) in the level of expenditures per pupil, the salaries of school personnel, and the demand for the quantity and quality of teachers services, then it suggests that the distribution of grants-in-aid does not (does) compensate districts for differences in community income. Using the standard terminology, if we observe no difference in the net patterns of resource allocation among these school districts, then we could say that the aid distribution is income neutral. The net differences in resource allocation are reported in column 4.

Even with the lower level of intergovernmental grants, the higher income districts still spend more on educational services, pay higher salaries (which presumably attract better quality school personnel), and maintain smaller classes. The increased quality of school personnel refers not only to the traditional experience and educational preparation, but also to other teacher characteristics (e.g., teacher verbal ability) that are not explicitly accounted for in district salary schedules. These other teacher characteristics are likely to be implicitly recognized in district policies in setting starting salaries, *ceteris paribus*. For example, using the estimates of the differential in starting teachers' salaries from Table 3 along with Levin's (1968b) esti-

¹⁷ State grants are largely based on assessed value of property in the district: The greater the assessed valuation of property, the smaller, in general, will be the state aid. To the extent that property in the district is residential, districts with relatively high assessed valuation of property are generally higher income districts. This result simply reflects the fact that higher income families exhibit a greater demand for housing services. Moreover, both state and federal governments provide categorical aid of which a substantial portion is directed toward improving educational opportunities for relatively disadvantaged children. Based on these considerations, one would expect higher income communities to be receiving a lower level of state and federal grants-in-aid than lower income communities.

mates of the implicit market price of teachers' verbal ability, the high-income districts could purchase close to eight additional units of teacher verbal ability with the net difference that they are willing to pay. Stretching these results a bit further, Hanushek's (1968) estimate of the marginal product of teacher verbal ability for white pupils indicates that those eight additional units of verbal ability purchased by high-income districts could purchase 1.43 additional units of achievement.¹⁸

The reader is cautioned not to take these results too seriously, as they were derived from a relatively small sample of California school districts (and elementary districts at that). In addition, the input elasticities estimated in this California study were somewhat smaller than those obtained by Alexander (1974) in a study of a much larger sample of California districts. If Alexander's estimated elasticities had been used, the estimated disparities between the high- and low-income districts would have been larger than those reported in Table 3.

Feldstein's (1975) estimates of the wealth-neutralizing effects of the Massachusetts state-aid formula suggest also that wealthier districts would indeed spend relatively more on educational services despite the attempts at equalization implied by the state's matching-grant formula. His estimates reveal a net positive elasticity of school spending with respect to property wealth equal to .19, that is, a 1% increase in property wealth leads to a .19% increase in school spending despite the equalizing impact of the state-aid formula.¹⁹

EDUCATIONAL COST DIFFERENTIALS

One of the most neglected factors in the analysis of the determinants of school spending and budget allocation is the variation in the prices of school inputs. The problem does not involve a failure to recognize the importance of input price differentials, but rather involves a lack of readily available measures of quality-adjusted input prices. In particular, average salaries or even the parameters of salary schedules for school personnel reflect, to some degree, quality differences and hence matters of local choice. Researchers are often forced

¹⁸ For the purpose of making this estimate of the additional units of achievement purchased by higher income communities, a constant marginal product of teacher verbal ability is assumed.

¹⁹ Using the Feldstein notation,

$$\hat{\alpha} = \hat{\beta}_W + \hat{\beta}_P \cdot \hat{\gamma}_{WP} = .37 - (1.0)(.18) = .19.$$

The "hats" indicate estimates.

to use variables believed to be related to input price variation as proxies for price effects. The difficulty with this approach is in the interpretation of the results. For example, how do we make inferences regarding price elasticities or how do we separate *supply* price effects from the impact of differences in educational *need*, e.g., in the case where a variable such as racial composition of the student body could affect not only working conditions for, and hence the supply of, teachers but also could serve as a proxy for pupil-need? Clearly, to the extent that input prices (adjusted for quality) are correlated with such factors as district fiscal capacity or intergovernmental grants, the estimates of expenditure elasticities with respect to any of these variables, and hence measures of equalization, will be biased.

The salaries of professional school personnel, which account for about 80% of school budgets, are the most important source of variation in educational expenditures. In order to adjust personnel salaries for variations in quality, it will be necessary to determine the degree to which salary variation is a matter of local choice versus the degree to which it is outside the control of local decision-makers.

A Conceptualization of the Market for School Personnel

The theoretical structure used to characterize the market for school personnel is based on the theory of hedonic prices and implicit markets as outlined in Rosen (1974). Viewed in this context, labor-market transactions involve a mutual exchange of labor's productive attributes and the attributes of the work place that define working conditions. In a specific application of the hedonic price technique to the market for teachers, Antos and Rosen (1975) describe the labor-market transaction as follows:

Teachers sell the services of their labor, but simultaneously purchase utility bearing characteristics of the schools in which they work. On the other side of the bargain, school administrators purchase desired teachers' services and jointly sell characteristics of schools and students to their teachers. Every contract quotes a price for the total package of labor services and on-the-job consumption, and the content of the package varies from school to school. Hence, comparisons of wage rates across teacher characteristics and consumption attributes yield a functional relationship from which it is sometimes possible to impute prices for various dimensions of the underlying exchange package. The observed relation between salaries, teacher characteristics and school characteristics is determined by the market. (p. 1)

The resulting empirical relation between teachers' salaries, teacher characteristics, and school characteristics is referred to as the hedonic price (earnings) function or market price schedule of teachers.

*A Behavioral Approach to Measuring
Supply Price Differentials*

Within this conceptualization, to what extent is the variation in the salaries of teachers (or other school personnel) a matter of choice to local decision-makers? For this purpose, the factors that determine personnel salaries may be divided into two parts as follows:

1. The factors that are *endogenous* to local school decision-makers (i.e., the *demand* factors) include:
 - a. personal *quality characteristics* (e.g., professional experience, educational preparation, and other ability characteristics such as teacher verbal ability) and
 - b. working conditions (e.g., class size and availability of instructional materials).
2. The factors that are *exogenous* to local school decision-makers (i.e., the *supply* factors) include:
 - a. characteristics reflecting the *relative attractiveness* of employment opportunities across schools and districts (e.g., characteristics of pupils and local crime rates) and
 - b. the conditions that characterize the *local labor market* in which the district is located (e.g., cost of living, wages in other professional occupations, competitiveness of the labor market, and general attractiveness of the region as a place to live).

Formally, the earnings function, the parameters of which are determined in the markets for various school personnel, may be expressed as follows:

$$(11) \quad \text{Sal}_i = s(\mathbf{q}_i, \mathbf{w}_i, \mathbf{z}_i)$$

where

- Sal_{*i*} = the annual salary of the *i*th individual,
s(·) = the hedonic earnings function (market price schedule),
 $\mathbf{q}_i$ = the vector of personnel quality characteristics (e.g., experience, education, and ability traits) of individual *i*,
 $\mathbf{w}_i$ = the vector of endogenous working conditions (e.g., class sizes) of individual *i*, and
 $\mathbf{z}_i$ = the vector of exogenous factors, associated with individual *i*, of personnel to the local district (i.e., relative attractiveness of the district and local labor market conditions).

The parameters (i.e., estimated regression coefficients) of the earnings function convey to school decision-makers the increment in sal-

ary that must be paid in the market for each of the attributes contained in the vectors (q, w, z). These increments are reflected either explicitly (as are those paid for experience and education) or implicitly (as are those paid for such attributes as teacher verbal ability or district characteristics such as racial composition of pupils) in district salary schedules.

Table 4 presents a sample of some of the more important variables, along with the signs of their estimated coefficients, that appear in selected studies in which hedonic earnings functions for teachers were estimated. In general, one observes that the teacher quality characteristics such as educational preparation, professional experience, and teacher verbal ability lead to higher salaries, *ceteris paribus*. Levin (1968b) reports, for example, that an additional year of schooling is associated with a salary differential of about 7%, an additional year of experience leads to a salary increment of about 1%, and each additional unit of verbal ability is associated with a differential of about .3% in a teacher's salary. Antos and Rosen (1975) report very similar results with respect to their sample of teachers. Levin also finds that elementary-education majors appear to have a lower implicit market price than any other college major. One would suspect that this is a result of the lower opportunity costs facing the elementary-education major in the market. In particular, science and mathematics majors, because of their relatively large variety of opportunities in the labor market, receive higher salaries. For those familiar with the structure of school district salary schedules, which presumably pay any teacher with equivalent educational preparation (in years of schooling) and professional experience the same salaries, this may appear to be an anomaly. The interpretation of this result in the teachers' market is that for a given salary, a school district will be able to employ elementary-education majors who are superior in some other respects to science and mathematics majors. A similar result appears in analyzing the salary differentials between males and females. Virtually every study of teacher earnings reports that males receive higher salaries than females, other things being equal. This result is quite consistent with the results of studies (e.g., Oaxaca, 1973) of male-female wage differentials in other labor markets and reflects the fact that males have higher opportunity costs in the labor market (which perhaps is, in part, due to discrimination). Once again the interpretation of this apparent anomaly is that for a given salary, a school district will be able to employ better quality female than male teachers, *ceteris paribus*.

Looking for a moment at some of the determinants of teachers' salaries that are outside the control of local decision-makers, one finds

TABLE 4
The Impact of Selected, Significant Variables
on the Determination of Teachers' Salaries

Independent variable	Sign of estimated coefficient	Study or studies in which variable was used ^a
(1) <i>Teacher traits</i>		
Years of schooling	+	A & R, C, L, T & W
MA relative to BA	+	A & R, C,
Years of experience	+	A & R, C, L, T & W
Years in present district	+	A & R, C
Teacher verbal ability	+	A & R, L
Undergraduate major ^b		
Math-science	+	L, T & W
Humanities	+	L, T & W
Social science	+	L, T & W
Miscellaneous	+	L
Elementary education (comparison group)	-	
Male	+	A & R, C, L, T & W
(2) <i>Endogenous working conditions</i>		
Teacher-pupil ratio	-	C
Per-pupil expenditure (instructional supplies)	-	C
(3) <i>Exogenous district characteristics</i>		
Percent minority pupils	+	A & R, C, L
Percent pupils—Free lunch ^c	+	A & R
Pupil achievement	-	A & R
Dropout rates	+	A & R
Attendance rates ^d	-	A & R
Index of school problems	+	L
Central city over rural	+	A & R, C, T & W
Suburban over rural	+	A & R, C
District or school size	+	A & R, C

^a Code for the studies of teachers' salaries: Antos and Rosen (1975) = A & R, Chambers *et al.* (December 1976) = C, Levin (1969) = L, Turnbull and Williams (December 1976) = T & W.

^b Each of the undergraduate majors was compared with elementary education majors for determination of relative salary differential.

^c Free lunches are provided to pupils who are classified as relatively disadvantaged.

^d Attendance rate refers to the ratio of average daily attendance to a measure of enrollment.

that districts with large proportions of minority pupils, with relatively low socioeconomic-status pupils, with relatively low achievers, and with relatively low attendance rates will tend to pay relatively higher salaries to attract a given quality of teachers' services. In fact, one generally finds that districts exhibiting these and other kinds of traits that characterize pupils attending central-city schools have to pay relatively higher teachers' salaries. Finally, it has been discovered that districts in large metropolitan areas tend to pay higher salaries than do nonmetropolitan districts, *ceteris paribus*. These results probably reflect the relatively intense competition and the higher costs of living that tend to characterize metropolitan relative to nonmetropolitan regions (see Kenny, Denslow, & Goffman, 1975, for a discussion of costs-of-living differences in urban versus rural regions).

It is, in fact, the differentials in the salaries of school personnel attributed to the (exogenous) *supply* factors that are of concern in the determination of variation in the *cost* of educational services. The value of a dollar's worth of state aid varies across school districts depending upon the conditions that determine the local supply and, therefore, prices of school inputs. For the purposes of measuring these *supply*-cost differences, it is necessary to determine which of the factors influencing teachers' salaries are in fact endogenous to local school decision-makers.

Some of the previous attempts at constructing teacher-cost indices make arbitrary assumptions about which characteristics of school personnel should be held constant in order to construct the cost index (see Wasserman, 1963; Brazer, 1974). In effect, the question that each of these studies must address is, "Which teacher characteristics affect the quality of school services?" For example, the NEA and Woollatt cost indices assume that teachers' education and experience are related to quality throughout the full range of these variables, the New York State Education Department index assumes that educational quality is unrelated to education and experience of teachers, and Brazer constructs alternative indices using various combinations of these assumptions about the relation between school quality and teacher experience and education.

Viewed in the context of the behavioral approach proposed in this chapter, the appropriate question posed by these studies should be, "Which teacher (or other school personnel) characteristics do local school decision-makers (i.e., school boards in conjunction with high-level school-district administrators) *perceive* as contributing to school quality?" In terms of Equation 11, we are specifically interested in isolating the impact of the variation in the *supply* factors (z) on the

salaries of school personnel while the decision (or endogenous) variables q and w are held constant. This will provide policymakers with information on the variation in the cost of a given quality of school personnel across school districts where personnel quality is defined by the observed market behavior of school decision-makers.

In view of the analysis presented above, it should be apparent that the cost-of-living index currently in use in Florida to equalize the purchasing power of state school aid is incomplete. The cost-of-living index is but one component in the work-choice decisions that affect the salaries of school personnel and hence the cost of educational services. A more complete index must necessarily account for the compensating differentials associated with other factors affecting the desirability of living and working in different school districts (see Kenny et al., 1975, for a discussion of some additional specific problems with the Florida price-of-living index).

*Seniority, Tenure, and the Implications
for the Behavioral Approach*

One difficulty encountered in using the behavioral approach to assess educational quality involves the impact of the constraints on the choice of personnel quality imposed by the tenure and seniority provisions of the education codes and/or union contracts. In effect, these tenure and seniority provisions, while allowing districts to choose the number of teachers to be employed, constrain the choice of which teachers (and therefore which combination of teacher traits, q) will be employed. This results from the fact that seniority serves as the basis for the order of dismissal of school personnel—that is, those with the least seniority are dismissed first in response to a decline in enrollment or the elimination of educational programs (see Chambers, 1975, pp. 55–59). The quality characteristics of school personnel can therefore only be adjusted at the margin through newly hired staff.

The empirical implication of this constraint is that the level of employment of the constrained characteristic(s) will not vary systematically across districts according to variations in relative input prices and school budgets. However, the evidence that employment of these teacher characteristics does not respond systematically to changes in prices and budgets may be interpreted in three ways:

1. The particular teacher characteristic is perceived as contributing to educational quality but, as Frey (1973) has hypothesized, because of the structure of the perceived educational technology, "once in equilibrium the school board will continue to be on

its equilibrium 'expansion path' simply by increasing or decreasing the number of teachers" (p. 11), leaving unchanged the average quality of teachers;²⁰

2. The teacher characteristic is a valued trait in terms of improving educational quality, but school officials are constrained by the tenure and seniority provisions in their choice of the employment level of the characteristic; or
3. School officials simply do not perceive the characteristic as one that contributes to improved educational quality and hence do not respond in systematic ways to change the employment level of the particular teacher trait when input prices or school budgets change.

Empirical evidence necessary to sort out the three alternative explanations is somewhat mixed. Sorting out these alternatives has become important in deciding how to treat teacher experience and training, since neither of these teacher characteristics has been shown in production function analysis to be particularly important in the determination of pupil achievement. However, using the behavioral model, some studies (Alexander, 1974; Barro & Carroll, 1975; Chambers, 1978) have reported that school budgets are a significant determinant of the variation in employment of teacher education, and in certain instances similar results have been reported for teacher experience. This would appear to rule out Frey's explanation in that there was some evidence that movements along the school district's expansion path (as reflected by the response to budget increases) do involve increases in teacher quality. Furthermore, this evidence is consistent with the hypothesis that these traits (experience and education) of teachers are valued in improving school quality, which appears to rule out the third explanation suggested above.

²⁰ Frey (1973) chose a Cobb-Douglas form for this educational quality function for the school district. His rationale was that teacher quality and the teacher-pupil ratio should enter the function multiplicatively, since teacher quality would obviously have no meaning in a district without any teachers. However, one could just as well have specified a quadratic-functional form that satisfies Frey's criterion and yet does not rule out the possibility that district wealth would affect the district's choice of teacher quality.

Whether Frey's theoretical conclusions are correct is not really the important issue. The existence of a relationship between district wealth and the demand for teacher quality is clearly an empirical proposition, and, therefore, Frey's error is in ruling out the possibility of such a relationship, *a priori*. In fact, even Frey's own empirical results, which reveal a positive and statistically significant relationship between the wealth of a school district and the wages paid, dispute his theoretical conclusions. The only vindication for Frey's theoretical conclusion is the fact that the elasticity of wages with respect to district wealth is relatively small.

In favor of the second explanation (the tenure constraint), there is evidence reported by Chambers (1975) that, "because of the constraints imposed by teacher tenure arrangements on district decision making, school officials are unable to adjust the level of teacher experience downward to its optimal level" (p. 148). An implication of these empirical results is that school decision-makers would prefer a higher rate of turnover among teachers, allowing for the replacement of the older, relatively more experienced teachers with the newer, less experienced teachers. A higher rate of turnover increases the ability of the district to adjust downward the average level of experience of a teaching staff with "too much" experience.²¹ Barro and Carroll (1975), on the other hand, report:

Findings about the effects of budget changes on average teacher experience and training should be discounted heavily because there is evidence that those outcomes are determined mainly by choices of individual teachers rather than by choices of district officials. (p. xi)

Given the relatively low explanatory power of the demand equations for teacher experience and education (R^2 tends to run between about .20 and .40), one would have to say that the evidence on the value of teacher experience and training as perceived by local decision-makers is inconclusive. Therefore, without further evidence, we are unable to determine whether these traits are endogenous or exogenous to local school district decision-making.

One way of dealing with this problem is to focus attention on the determinants of the characteristics of the newly hired teachers across local school districts. In attempting to estimate the demand for the experience or educational preparation of newly hired teachers, it is necessary to take account of the lower-bound constraints on these variables. Districts cannot hire teachers with negative years of experience and in some states are effectively prevented from employing

²¹ Presumably, given a long enough period of time, *ceteris paribus*, the constraints implied by the tenure laws would not be binding, since the district would be able to exert influence over teacher turnover rates and, hence, the average experience of its current staff. This influence would operate through the district's policies with regard to setting salary schedules which would influence turnover decisions of teachers. Therefore, the tenure constraints actually reflect the existence of a short-term disequilibrium caused by some exogenous factors operating on teacher turnover decisions. The recent surplus in the market for teachers and the economic conditions existing in the early 1970s could have altered choice patterns, which ultimately would affect trade-offs between wages and turnover. With so many teachers awaiting employment opportunities, currently employed teachers may be less likely to leave their positions for fear they will be unable to acquire subsequent employment. The implication of this apparent reduction in teacher turnover is that school districts are finding it increasingly difficult to make the desired adjustments in the level of teacher quality.

teachers with less than a BA degree. Thus, an estimation technique such as the one outlined by Tobin (1958) which takes into account this lower limit on the dependent variable must be used to estimate the demand equations for teacher experience and education.²²

Figure 1 illustrates this technique. For expository purposes it is assumed that all else is constant across districts except the school budgets and that a linear relationship exists between demand for new teacher experience and the budget. As can be seen from Figure 1, districts with a budget $E > E^*$ will be operating along the demand relationship, while districts with a budget of $E \leq E^*$ will be operating along the constraint and will be hiring inexperienced teachers. In fact, districts operating at $E < E^*$ could be said to desire less than zero experience. That is, if they could, district decision-makers would hire negative years of experience among their newly hired teachers in order to adjust the overall level of experience of their teaching staff downward.²³ Presumably, one could use the parameter estimates to extrapolate below zero the estimated demand for teacher experience to determine the degree to which districts are employing more overall teacher experience (or, for that matter, any other teacher trait) than they would in the absence of the constraint.²⁴

There still remains a problem with this technique in terms of its capability to reconcile the three explanations for any observed independence of demand for teacher traits from variations in school input prices and budgets. For example, if enough districts are operating on

²² Tobin demonstrates that ordinary least squares estimators of the parameters of a relationship with a limited dependent variable will be biased. He discusses a maximum likelihood method of estimation that explicitly takes into account the truncated nature of the distribution of the dependent variable.

²³ Let $X_d^{(n)*}$ be the demand for average experience of newly hired teachers. Suppose further that extrapolation below zero of the demand function in Figure 1 implies $X_d^{(n)*} < 0$. Then, letting θ be the turnover rate among teachers and $X^{(r)}$ be the average experience of teachers already employed by the district, the demand for overall average teacher experience is given by

$$X_d^* = (1 - \theta)X^{(r)} + \theta \cdot X_d^{(n)*} < (1 - \theta)X^{(r)} = \bar{X}$$

or

$$(i) \quad X_d^* < \bar{X}$$

for $X = \bar{X}$, $X_d^{(n)} = 0$. Note that $X^{(r)}$ is assumed to be exogenously determined in the short run since teacher turnover is rarely, if ever, an involuntary act.

²⁴ Using the results of Equation (i) in Footnote 23, one can then determine the endogenous component of average teacher experience as X_d^* , and the exogenous component as $(\bar{X} - X_d^*)$ represents an element of educational costs. Whether or not "excess experience" should be accounted for in a cost-of-education index will depend upon an assessment of the ultimate impact of district incentives in making efficient adjustments.

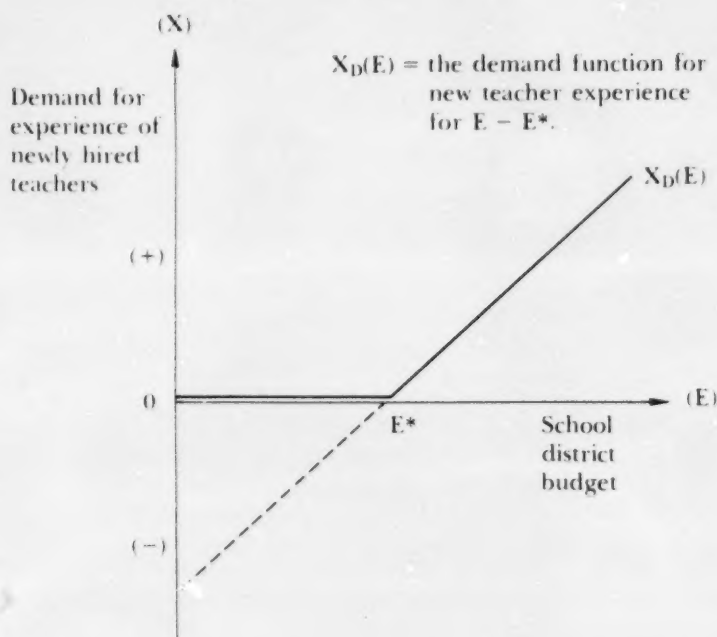


FIGURE 1. The relation between demand for experience of newly hired teachers and school district budget, holding all else constant.

the lower-bound constraint for teacher experience (e.g., as evidenced by their hiring only inexperienced teachers), then the empirical evidence will be indistinguishable from the hypothesis that teacher experience is not perceived by local decision-makers as contributing to educational quality. To make this distinction, it is necessary to have districts included in the sample that are observed to hire other than inexperienced teachers. If we still observe no relation between the demand for teacher experience and the variations in school input prices and budgets, then we will be in a better position to reject the hypothesis that teacher experience is a valued trait.

The ultimate reconciliation of the problem of assessing the endogeneity of teacher traits such as experience and education will have to await further investigation into the supply of new teachers and into the supply of teacher traits to the market, which is in part determined

by the responses of currently employed teachers to the monetary incentives built into school-district salary schedules.

*A Cost of Education Index
and State Aid Allocations*

Chambers, Odden, and Vincent (1976) have made the first attempt to estimate and employ a hedonic earnings function for teachers to calculate a teacher-cost index. Because of the limitations on time and funds under which the study was conducted, no attempt was made to use the behavioral approach to separate systematically the endogenous and exogenous variables. Hence, it was necessary to make some arbitrary assumptions. Using the categorization implied in the theoretical specification of Equation 11, we estimated and calculated a teacher-cost index using a large random sample of teachers in the state of Missouri. Then using the average proportion of the budget devoted to teachers' salaries by Missouri school districts, we developed an adjusted index which could be applied to total current educational expenditures.

Some descriptive statistics for the index are reported in Table 5. As expected, the teacher-cost index reveals generally higher costs in the central city and suburban districts relative to the rural districts and higher costs in the districts located in the major metropolitan areas

TABLE 5
Descriptive Statistics for the Teachers' Cost Index
Across Local School Districts in Missouri, 1974-75

Type of district	Mean	Standard deviation	Minimum	Maximum
For all districts	1.00	.06	.90	1.17
Central city and suburban districts	1.08	.06	.96	1.17
St. Louis metropolitan area and surrounding counties	1.10	.05	.98	1.17
Kansas City metropolitan area and surrounding counties	1.05	.05	.95	1.12
Rural districts	.99	.04	.90	1.09

relative to those in the nonmetropolitan regions of Missouri. Both the mean and the range of values taken on by the various categories of school districts exhibit the same pattern.

There are two rather evident and important implications of including a cost-of-education index in the state-aid allocation to local school districts. The first is that per-pupil state aid to metropolitan school districts will, on the average, be increased by application of the cost index (Chambers et al., 1976, Table 8). Second, the use of a cost-of-education index to adjust state aid raises total expenditures allocated by the state to education *ceteris paribus*, because the higher costs of education (and hence the higher cost indices) tend to occur in the more populous metropolitan school districts. As we conclude in our discussion of cost-of-education indices:

These results indicate . . . that the use of cost indices has political implications. Cost indices will increase state aid, on average, to metropolitan school districts. Politically considered, the use of cost indices could be a factor in developing a city-suburban coalition on school finance matters. Since rural areas either lose state aid or are left harmless by cost indices, other factors, such as per capita or per pupil income factors, may have to be incorporated into a formula to gain the support of rural areas for the use of cost indices. Since rural areas, in general, have lower per capita incomes they will receive relatively more state aid when income factors are part of an equalization aid formula. (p. 30)

Interestingly, these conclusions lend some practical support for the behavioral approach to measuring fiscal capacity. For the purposes of equalization, it would seem imperative that we take account of all of the fiscal variables, such as community income per capita, that have an impact on the ability of local school districts to finance educational services.

One final set of issues that should be raised involves the efficiency and equity effects of including an educational cost index in state-aid formulas. As Kenny et al. (1975) state,

When states give more funds per pupil to districts where educational inputs are more expensive, families have less incentive to move to areas where education of a given quality can be obtained more cheaply. This drives up the cost of living and hence the cost of education; eventually these states will be able to purchase less real educational inputs per dollar. (p. 203)²⁵

This statement ignores the equity implications of the fact that moving

²⁵ However, the authors do note that their argument would "not apply to compensation teachers might require for what they consider undesirable characteristics of students, since the students would retain these characteristics wherever they live" (p. 203, n. 19).

may not be a viable option for all families (e.g., due to discrimination in the housing market). Moreover, by providing extra state aid to the central cities to compensate for high input prices, states reduce the incentives for whites to move to the suburbs. Reducing white flight may result in achievement gains associated with positive peer influences (see, e.g., the discussion in Kiesling, 1971, pp. 28-29) and may well reduce further increases in educational costs associated with rising proportions of black pupils. Even assuming that a net increase in educational cost does result, as Kenny et al. (1975) suggest, the economic value of the potential increase in educational outcomes would have to be weighed against the cost to assess the net impact on efficiency. Which of these statements more accurately depicts the impact of including an educational cost index in a state-aid formula will have to await further empirical investigation.

AN AGENDA FOR FUTURE RESEARCH AND SOME CONCLUDING REMARKS

Any analysis of public policy necessarily leads to important questions of political and social ideology. It has been the purpose of this chapter to present a discussion of the literature on school district behavior within the context of its implications for educational policy. It has also been the intention to develop some practical approaches to dealing with the concept of equal educational opportunity as it relates to the measurement of such factors as educational quality, wealth or fiscal disparities, and differences in the cost of educational services. This is not to say that the approach outlined in this chapter is the only practical approach available, but rather that it is a feasible approach that can be defended within the context of the existing structure of public education. The analysis of what the organizational structure should be or how it might be changed involves a different set of policy issues that are beyond the scope of this chapter.

There remains a great deal of substantive policy research to be carried out to improve our understanding of the process of resource allocation in public schools and of the relation of this process to the technological conditions that characterize the production of educational services. We need to expand the data bases that form the foundation of the studies of budget determination and allocation. The expansion of these data bases should be directed toward increasing the scope of school inputs examined within the context of budget allocation studies and toward improving our ability to relate this process of budget allocation to the alternative measures of fiscal capacity that affect the determination of educational budgets. Better

data in both these areas will be necessary for making policy judgments with regard to equal educational opportunity. Related to these issues, further investigation is needed to identify the long-run and short-run supply curves for teachers in regional labor markets. Finally, to resolve the issue of the endogeneity of particular teacher traits, it will be necessary to examine the supply of, and demand for, the characteristics of newly hired teachers and the relation of this market to the supply of, and demand for, the characteristics of teachers already employed in school systems. There are at least two other critical areas of study related to the analysis of resource allocation in public schools: (a) the determinants of educational need and (b) the impact of residential location choices of families on school decision-making and vice versa. Each of these issues is outlined in some detail below.

Educational Need

Conventional wisdom suggests that different kinds and combinations of school resources are required to provide a given quality of school services to different categories of pupils. For the purpose of need classification, pupils might conceivably be categorized according to certain ability traits (e.g., entry-level achievement test scores or IQ measures), socioeconomic background, or racial and ethnic characteristics. One would suspect that the perceptions of school decision-makers with respect to the relationship between the level of educational quality and the combinations of school inputs will vary systematically according to some relevant set of personal characteristics of the student population. For example, most school officials are likely to believe that it will cost more and require different patterns of expenditure to provide a given quality of school services to pupils of low socioeconomic status. From the perspective of public policy, the objective would be to determine which personal characteristics of pupils are associated with differences in pupil-need. Having identified these characteristics, one might then proceed to determine the extent to which differences in educational costs may be attributed to the variations in the composition of pupils with respect to these characteristics.

For school districts, the variations in pupil-need that affect the costs of school services are determined exogenously since, for all intents and purposes, student composition tends to fall outside the control of local school officials. Hence, a dollar's worth of state aid will vary in the quality of educational services it will buy because of variations in pupil-need across local school districts, *ceteris paribus*.

The behavioral approach can potentially help identify which characteristics of pupils reflect perceived differences in need. This can be accomplished by observing which pupil characteristics have

significant effects on the patterns of employment of school inputs, holding constant input costs and educational budgets. Given this information, one might be able under certain assumptions to determine the impact of perceived pupil-need on educational costs. If such a methodology could be devised, decisions on expenditure adjustments to account for pupil-need would not have to be carried out through arbitrary weighting structures developed by state policy-makers (as is currently done in most states).

Assessment of differences in pupil-need requires both investigation of school district behavior and further investigations into the nature of the educational production process. As suggested previously, such an integrated approach is essential in unraveling the interactions of educational taste and technology.

Models of Residential Location

Perhaps the largest void in the research on analysis of resource allocation in public school districts is the lack of any systematic studies of the relation between the residential location decisions of individual households and the resource allocation decisions of local public school officials. Each of these strands of research has been carried out somewhat independently. Moreover, because of the manner in which residential location models are specified (see, e.g., Edelstein, 1974; Straszheim, 1975; Gustely, 1976), it becomes apparent that a consolidation of these models with models of resource allocation in public schools must include a consideration of the resource allocation decisions made by other local units of government.²⁶ Specifically, community desirability and hence property values are affected not only by the quality of, and taxes levied for, educational services but also by the quality of, and taxes levied for, other community services. The basic policy issue involves the determination of the impact residential location choices of families have on property values and local school decision-making and the impact local decision-making has on the residential location choices of families and hence on property values. It should be clear that this specification implies a simultaneity problem and that, in order to estimate the structural equations that represent the system, it will be necessary to use an estimation technique that explicitly accounts for the existence of these interrelationships.

One interesting implication of this discussion concerns the modification of the behavioral approach to assessing educational quality, wealth disparity, and cost differentials. For example, rather than

²⁶ For a first attempt to consolidate these models of resource allocation in the local public sector with the determination of local property values, see Meadows (1976).

determining which school inputs are perceived as contributing to educational quality by examining the behavior of school district decision-makers, one could instead examine which particular combinations of school inputs tend to be capitalized into residential land values. Those inputs exhibiting positive capitalization effects are presumably those perceived by local residents as contributing to educational quality. Using this approach we are in a sense relying on a more conventional concept of consumer sovereignty to help us define and measure differences in school quality.

With respect to measures of wealth and fiscal disparities between school districts, integration of these two models would make more evident one of the basic defects of using property value as a measure of ability of a school district to finance educational services. In the words of Reischauer and Hartman (1973), "property values per pupil will fail to measure the relative abilities to pay whenever residential values have built into them the tax differences among districts" (pp. 69-70). Property values will tend to be higher in those districts exhibiting relatively lower tax burdens necessary to raise a dollar per pupil for education.²⁷

Concluding Remarks

It should be evident from the foregoing analysis that an accurate accounting of the factors that affect the behavior of local school district officials will require the specification of a comprehensive model of resource allocation in public school districts, resource allocation by other local units of government, and residential location decisions by individual households. The major effort in this context should involve the integration of the already existing models of decision-making that characterize these various strands of research.

At this point a word of caution seems necessary regarding the proposed behavioral approach to assessment of educational quality. One might be tempted to draw the conclusion that by relieving researchers and state educational policymakers from making judgments about what educational quality is, the behavioral approach is somehow value free, that is, the values of researchers and state policymakers are not imposed on the system. However, the reader should recognize that a value judgment has been made within the context of the behavioral approach itself. The advocate of the behavioral approach is implicitly placing a value on the decentralization of decision

²⁷ This impact on residential property values might well occur in areas with higher proportions of nonresidential property in local communities. This effect might also occur in response to differences in efficiency with respect to the supply of educational services.

making that is consistent with increased personal freedom and individual choice. In the short run this market approach provides the school decision-makers (who are supposed to represent the preferences of the local constituency) with the power to determine, through their observed behavior, what school quality is, while in the long run some families have the option of voting with their feet by deciding to locate in communities that exhibit similar preferences regarding assessments of educational quality.²⁸

REFERENCES

- Alexander, A. J. *Teachers, salaries, and school district expenditures* (R01588-FF). Santa Monica, Calif.: Rand, October 1974.
- Antos, J. R., & Rosen, S. Discrimination in the market for public school teachers. *Journal of Econometrics*, 1975, 3.
- Ashenfelter, O. The effect of unionization on wages in the public sector. *Industrial and Labor Relations Review*, 1971, 24(2), 191-202.
- Averch, H. A., Carroll, S. J., Donaldson, T. S., Kiesling, H., & Pincus, J. *How effective is schooling? A critical review and synthesis of research findings*. Englewood Cliffs, N.J.: Educational Technology Publications, 1974.
- Barro, S. M. *An approach to developing accountability measures for the public schools*. Santa Monica, Calif.: Rand, 1970.
- Barro, S. M. *The impact of intergovernmental aid on public school spending*. Unpublished doctoral dissertation, Stanford University, 1974.
- Barro, S. M., & Carroll, S. J. *Budget allocation by school districts: An analysis of spending for teachers and other resources*. Santa Monica, Calif.: Rand, 1975.
- Bowles, S. Toward an educational production function. In W. L. Hansen (Ed.), *Education, income and human capital*. New York: National Bureau of Economic Research, 1970.
- Brazer, H. E. Adjusting for difference among school districts in the costs of educational inputs: A feasibility report. In *Selected papers in school finance*, 1974. Washington, D.C.: Department of Health, Education, and Welfare, Office of Education, 1974.
- Brown, B. W., & Saks, D. H. The production and distribution of cognitive skills within schools. *Journal of Political Economy*, 1975, 83(3), 571-594.
- Carlsson, R. J., & Robinson, J. W. Toward a theory of public employment wage theory. *Industrial and Labor Relations Review*, 1969, 22(2), 243-248.
- Carnoy, M. *Schooling in a corporate society*. New York: McKay, 1972.
- Carroll, S. J. School district expenditure behavior. *Journal of Human Resources*, Summer 1976, pp. 317-327.
- Chambers, J. G. *The impact of collective negotiations for teachers on resource allocation in public school districts*. Unpublished doctoral dissertation, Stanford University, 1975.

²⁸ Of course, as mentioned previously, this option of moving is not open to all families on an equal basis. Low income and discrimination in housing patterns tend to reduce and perhaps effectively eliminate this option for some families.

- Chambers, J. G. *The impact of bargaining on the earnings of teachers: A report on California and Missouri*. Paper presented at the U.K.-U.S. Conference on Teacher Markets, Chicago, December 1976.
- Chambers, J. G. The impact of collective bargaining for teachers on resource allocation in public school districts. *Journal of Urban Economics*, July 1977.
- Chambers, J. G. An analysis of resource allocation in public school districts. *Public Finance Quarterly*, April 1978.
- Chambers, J. G., Odden, A., & Vincent, P. E. *Cost of education indices among school districts*. Denver, Colo.: Education Commission of the States, 1976. (Monograph)
- Coleman, J. S., Campbell, E. Q., Hobson, C. J., McPartland, J., Mood, A. M., Weinfeld, F. D., & York, R. L. *Equality of educational opportunity* (popularly known as the Coleman Report). Washington, D.C.: Department of Health, Education, and Welfare, Office of Education, Government Printing Office, 1966.
- Coleman, J. S., & Karweit, N. L. *Measure of school performance*. Santa Monica, Calif.: Rand, 1970.
- Coons, J. E., Clune, W. H., III, & Sugarman, S. D. *Private wealth and public education*. Cambridge, Mass.: Harvard University Press, Belknap, 1970.
- Edelstein, R. The determinants of value in the Philadelphia housing market: A case study of the main line 1967-1969. *Review of Economics and Statistics*, August 1974, pp. 319-328.
- Ehrenberg, R. G. The demand for state and local government employees. *American Economic Review*, 1973, **63**(2), 366-379.
- Ehrenberg, R. G., & Goldstein, G. S. A model of public sector wage determination. *Journal of Urban Economics*, 1975, **2**, 223-245.
- Feldstein, M. S. Wealth neutrality and local choice in public education. *American Economic Review*, 1975, **65**(1), 75-89.
- Frey, D. E. *Wage determination in public schools and the effects of unionization*. Paper presented at the Conference on Labor in Non-profit Industry and Government, Princeton, N.J., 1973.
- Future directions for school finance reform. *Law and Contemporary Problems*, Winter-Spring, 1974.
- Gustely, R. D. Local taxes, expenditures and urban housing: A reassessment of the evidence. *Southern Economics Journal*, April 1976, pp. 659-665.
- Hanushek, E. *The education of Negroes and whites*. Unpublished doctoral dissertation, Massachusetts Institute of Technology, 1968.
- Kenny, L. W., Denslow, D., Jr., & Goffman, I. Measuring differences among the Florida school districts in the cost of education: An alternative approach. In *Selected papers in school finance 1975*. Washington, D.C.: Department of Health, Education, and Welfare, Office of Education, 1975.
- Kiesling, H. J. *Multivariate analysis of schools and educational policy* (P-4595). Santa Monica, Calif.: Rand, 1971.
- Ladd, H. F. Local education expenditure, fiscal capacity, and the composition of the property tax base. *National Tax Journal*, June 1975, pp. 145-158.
- Levin, H. M. The failure of the public schools and the free market remedy. *Urban Review*, 1968, **2**, 32-37. (a)
- Levin, H. M. *Recruiting teachers for large city schools*. Unpublished manuscript, Brookings Institution, 1968. (b)

- Levin, H. M. Measuring efficiency in educational production. *Public Finance Quarterly*, 1974, 2(1), 3-24.
- Lewis, H. G. *Unionism and relative wages in the United States*. Chicago: University of Chicago Press, 1963.
- Lindsay, C. M. A theory of government enterprise. *Journal of Political Economy*, October 1976, pp. 1061-1078.
- Meadows, G. R. Taxes, spending, and property values: A comment and further results. *Journal of Political Economy*, August 1976, pp. 869-880.
- Moynihan, D. P. Equalizing education in whose benefit? *Public Interest*, 1972, 29, 69-89.
- Musgrave, R. A., & Musgrave, P. E. *Public finance in theory and practice* (2nd ed.). New York: McGraw-Hill, 1976.
- Oaxaca, R. Sex discrimination in wages. In O. Ashenfelter & A. Rees (Eds.), *Discrimination in labor markets*. Princeton, N.J.: Princeton University Press, 1973.
- Owen, J. D. Toward a public employment wage theory: Econometric evidence on teacher quality. *Industrial and Labor Relations Review*, 1972, 25(2), 213-222.
- Pincus, J. *School finance in transition*. Cambridge, Mass.: Ballinger, 1974.
- Reischauser, R. D., & Hartman, R. W. *Reforming school finance*. Washington, D.C.: Brookings Institution, 1973.
- Rosen, S. Hedonic prices and implicit markets: Product differentiation in pure competition. *Journal of Political Economy*, 1974, 82(1), 34-55.
- Samuelson, P. A. Maximum principles in analytical economics. *American Economic Review*, June 1972, pp. 249-262.
- Straszheim, M. *An econometric analysis of the urban housing market*. New York: National Bureau of Economic Research, Columbia University Press, 1975.
- Tobin, J. The estimation of relationships for limited dependent variables. *Econometrica*, January 1958, pp. 24-36.
- Wasserman, W. *Education price and quantity indexes*. Syracuse, N.Y.: Syracuse University Press, 1963.
- Zabalza, A. *The determinants of teacher supply*. Paper presented at the U.K.-U.S. Conference on Teacher Markets, Chicago, December 1976.

Chapter 4

ECONOMIC ANALYSIS AND THE PUBLIC SUPPORT OF HIGHER EDUCATION: THE DIVERGENCE OF THEORY AND POLICY

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Educational policy analysis, and especially the policy analysis of American higher education, presently offers a curious example of the tenuous relationship between social science and public policy. The traditional methods of macro-educational intervention—public control and subsidization—would appear to be under question everywhere but in actual practice. The fact that the traditional approaches persevere even after the scholarly rejection of their theoretical bases and the empirical revelation of their practical failures is indicative of two forces: the special interests that are well served by the present system and the mythology that surrounds the American higher educational experience.

This chapter suggests how a greater degree of rationality and accountability might be introduced into the system of higher education. While much of the following discussion is applicable to all levels of education, this chapter concentrates on higher education as it exists in the industrialized economies. The emphasis on higher education is justified because it is at this level that the relative public costs and benefits of educational expenditures appear most divergent. Under the mistaken assumption that the rationale that can be used to justify expenditures on primary and secondary education is equally applicable to the tertiary level, most nations have expanded their higher education systems well beyond levels justified by the normal criteria for public investment. This is unfortunate in that it deprives other educational or noneducational activities of needed funds and helps

create a group of unemployed or underemployed graduates. These graduates, along with the university students who foresee similar employment conditions for themselves after graduation, can easily become a politically destabilizing force in addition to being an economically destabilizing one.

The present tension between research findings and programmatic operations has resulted in a great increase of interest in the historical development of the public role in higher education. Educational historians are approaching the subject with a much more skeptical view of the reasons for the public intrusion into the almost exclusively private domain of higher education in the late 1700s and early 1800s. As the higher educational systems evolved from consumption or culture-transmission devices to ones of investment in individuals, the rationale for public support should have undergone a concomitant transformation. Much of the present research has come about because of a need to understand how contemporary systems of higher education and their financing can be rationalized.

What is lacking in most of these historical studies is a theory against which the present reality and its genesis may be contrasted. Such a theory will be presented in this chapter. No assumption will be made here as to whether individual or collective control—market or command allocational systems—is the “natural” alternative. Rather, the question is viewed in terms of why higher education, originally conducted almost exclusively in private institutions, developed so rapidly as a public enterprise in Western nations and their former colonies in the 1870–1970 period (increasing in both quality and quantity) and why the present system is at such wide divergence with the theoretical standard that should apply.

During the last century, two forces have acted to redirect public attitudes toward higher education. The first force was the altered perception by the public of the function of higher education; it was increasingly seen as a locus for scientific research and innovation as well as a major caretaker of cultural traditions. The public similarly has come to view higher education as an institution where individuals are prepared for future employment (the investment nature of this process was discussed as early as the 1700s but the theoretical formulation of the investment model came with the work of Schultz and Becker in the late 1950s and early 1960s). This second role for higher education has also come to be seen as a means of increasing social mobility and achieving greater social equity. Until the last decade, insufficient attention was directed toward the applicability of those roles to higher education as opposed to the earlier, more democratically accessed levels of education.

In Europe and the United States, the new views of the role of higher education often coincided with the political interests of the governing forces of society. These groups saw potential benefits to themselves as employers and to their children, who were the most likely direct beneficiaries of expanded opportunities for higher education. The two world wars and the intervening international recession acted to blunt the forces promoting higher educational expansion. However, the three decades from 1945 to 1975 were to see public-financed higher education move into a position of dominance in developing as well as developed nations.

An interesting point of debate in the discussion of the growth of higher education concerns the role played by the early work of Schultz (1960), Denison (1962), and Harbison and Myers (1964) which attempted to show a causal link between educational expansion and economic growth. Some writers credit these and related research efforts with being an important determinant of the increase in the absolute and relative levels of public educational expenditures. It is currently popular to take a more questioning view and to describe the expansion process as largely one of politicians responding more to the social demand of secondary-school graduates for further education than to any supposed collective benefits in the form of social or economic development. Certainly, the higher education policymakers would have found many early criticisms of the simplistic education-growth linkage had they felt it necessary to study the subject in any detail. The work of Balogh and Streeten (1963) and Bowman (1962), among others, highlighted the inherent methodological problems with the residual techniques used by the education/economic-growth proponents in their early studies. In fact, the policymaker needed only to read the careful caveats that Schultz and Denison themselves added to their work to be able to understand the tentative nature of their conclusions. Given the negative weight of the above, the evidence would seem to be on the side of those (e.g., Benveniste, 1972; Jencks, 1973) who see social science research as normally affecting policy only when it coincides with the more directly political determinants of policy.

For whatever combination of economic rationale and political rationalization, the last three decades have been a period in which nations have promoted subsidized higher education with costs commonly reduced to the level of forgone earnings and no more. In some nations where special housing and consumption subsidies are available to students but not to the general population, and where unemployment rates for secondary-school graduates are high, the cost to the student for higher education has approached zero at the margin.

ECONOMIC THEORY AND HIGHER EDUCATIONAL FINANCE

When the public role in higher education is questioned, many observers are surprised that there is any need even to discuss such an issue. To them, public financing and control of higher education are the natural order of things (in fact, some nations are without any meaningful private higher education sector). While perhaps not "natural," the public role in higher education is both long-standing and firmly entrenched in most developed nations. While there are great variations in terms of the degree of central control of curriculum and access, all developed nations have endorsed the propriety of using general tax revenues for the subsidization of the higher educational process.

Even if it is well late in the historical development of higher education, it is still essential to review how the public role should have been analyzed. It is useful to stop here and ask what higher education would look like if it could be redesigned without having to take into account the "political realities" of the moment.¹ Within the standard theory of public finance, the economic functions of governments are derived from the existence of substantial external economies which would be sacrificed if production or consumption decisions were left solely to individuals or private firms.² External economies exist whenever the utility of one individual or group is affected by the self-interested actions of another individual or group. In the case of education it has been asserted that the education of an individual citizen not only benefits that person but also generates substantial and positive effects for other members of society. Advocates of public intervention go on to argue that unless the public acts to affect the educational decisions of individuals, there will be an underproduction of education relative to the optimum quantity for society.

¹ While writers may be criticized for failing to take into account the political limits on policy, there is the alternative danger that attention to political realities will curtail policy relevant to research. Since research itself plays a role in determining the political realities of a society, writers must always feel free to examine systems free of the immediate political limits on institutional change.

² The three major forms of rationale for public intervention in any activity are, first, to stabilize the economy; second, to distribute more equitably the products of the economy; and, third, to improve the allocative efficiency of the production system itself. There is no reason why education should be justified under stabilization policies any more (but perhaps less) than other economic activities should be, except to the extent that multiplier effects, time lags, etc., may differ among expenditure forms. Distribution questions are best handled directly through taxation and direct money transfers, although the income-redistributive effect of education can be considered an externality and thus part of the allocative rationale for government involvement.

An example will clarify this assertion. If individual X is deciding the amount of higher education in which he will invest, he will compare the relative benefits and costs of this investment. Assuming the costs to be represented by an amount C_X and benefits B_X , individual X , if acting rationally, will intuitively approximate either an internal rate of return of the investment and compare that with the cost of funds or calculate the ratio of net present value of benefits to costs and compare it with the benefit/cost ratios of other investments.³

The important consideration in the argument for educational subsidies is that, in his investment decision, X will not include any costs (negative externalities) or benefits (positive externalities) that accrue to others for whom he has no immediate concern. In the example of higher education, if the total benefit to all members of society, B_S , is greater than B_X , then the social optimum, derived from comparing B_S with C_S (assumed equal to C_X in most discussions), will require greater amounts of educational investment than will be forthcoming from the private decisions of individual X .

Up to this point the development of the subsidization argument is internally logical, although the advocates of public intervention are a little superficial in their treatment of how individual costs, individual benefits, and externalities are to be objectively determined. Full acceptance of the discussion up to this point, however, would not by itself justify any public intervention and certainly would not necessitate the subsidization programs that are the standard tool of intervention in higher educational systems today.

This is a critical point, one of such importance that it justifies an excursion into the economic theory of public investments. The first step is to clarify some of the terminology that has confused the debate over public support of education in recent years. Externalities have already been defined. Related concepts are those of social benefits and social costs. To most authors these are simply the total externalities—positive and negative, respectively—generated by an individual economic unit. Some authors expand the concept to include the effects of an action on the individual unit *plus* the external effects.

Under the latter definition, a social rate of return to education should include all benefits received and all costs (monetary and non-monetary) incurred by the individual being educated, his family, and

³ This comparison of benefits and costs is rarely explicit but it is intuitively part of the decision process. An important consideration, however, is that benefit/cost or rate-of-return analysis is best suited for individual rather than collective decision situations. The use of these models in public education and the resultant "failures" of educational policy can be traced in part to the inability of collective administrators to take into account the important nonmonetary effects (costs and benefits) of educational processes.

taxpayers supporting subsidies, as well as any monetary or psychic costs incurred by others who are now relatively less educated as a result of the increased education of the original individual. Unfortunately, most calculations of what is called a "social" rate of return consist only of adding an estimate of future tax-receipt increases (because of the educated persons' higher lifetime-income expectations) to the benefit side and the tuition subsidy of education to the cost side. At best this is a lifetime cash-flow/return statistic and at worst a totally misleading measure of society's interest in individual educational decisions.

That some authors use this flawed measure rather than the externality-based social rate-of-return measure described above cannot be excused on the grounds that the latter, true social rate is exceedingly difficult to calculate. Although certain writers purport to recognize the difference between the crude approximation and the desired measure, they often fall into the trap of drawing conclusions for which *only* the actual externality-based social rate of return could be applicable. Psacharopoulos (1973), for example, refers to the difference between the private and "social" rates of return as a possible basis for determining the level of subsidization to education. As will be shown here, even the optimal estimation of the social rate of return would not, by itself, allow such a determination.

Finally, some authors prefer to reserve the term *social benefits* for only those externalities which are not captured by a limited number of individuals but are available to all. An illustration of the difference between this concept of social benefits and that of externalities is that, in education, for example, one person's increased attainment may alter his political attitudes in such a way as to make him agree with political party M but not party N. While certainly a true externality, it cannot be construed as a benefit generally available to all since it is, in fact, of a zero-sum nature. It is a "cost" of education to members of party N even though a "benefit" to members of party M. However, if one believes that education increases a person's ability to think rationally, and all members of a society accept the idea that rational thinking is a preferred state for its citizens, then education can be seen to generate a benefit that is truly available to all. In this chapter, social benefit, social cost, and social rate of return will always refer to the externality-based concepts whether or not the externalities are generally available to all citizens.

A related concept in the literature of public finance is that of a "public good." A public good is any economic activity, the benefits of which are available to all *without exclusion*. The exclusion principle is one of the most important determinants of public involvement and

exists as a polar case of the externalities/social benefits example. In general public finance, national defense is commonly cited as the closest approximation in government activities to a pure case of a public good. Once produced, national defense is available to all citizens. There is no way to exclude users of the systems (i.e., no economical way to exclude them). The reality of the world is such, however, that national defense or any other public good is not in fact equally available to all. Because of differing political values or an unequal geographic allocation of defense priorities, the citizens of a country will probably place differing values on the utility they derive from expenditures for national defense. The fact remains that the good is potentially available to all and no one person or group can exclude others from its consumption.

Public intervention in the production of such public goods is justified since it would rarely be the case that a single individual or small group would be willing or able to pay all the costs for a good that benefits so many other people. One can imagine, for example, a case where an individual's antipathy toward litter is so great that he cleans up his immediate vicinity, but it is unrealistic to leave the litter collection for a whole city to the responsibility of individuals motivated only by their own tastes for cleanliness. Even if one individual were wealthy enough to pay for all the costs of such a public good, there would be questionable equity in his provision of a good consumable by all of society and certainly a problematic efficiency in it.

It is noteworthy that the public good/collective consumption case, which is the strongest of the arguments for public control and subsidization, is the argument least applicable to the case of higher education. Primary and secondary education, because of their production of basic economic and political skills and their increasing availability to all citizens, can be justified either on the basis of social benefits or, and more easily, on the basis of transactions cost. This latter justification follows the pragmatic line that there are certain activities that society has deemed necessary for all (health care, housing, and basic education are commonly cited) that may be provided more efficiently by the state than by the market. The form of provision may be through an unrestricted cash grant, a voucher to be transferred to the supplier of the consumer's choice, or a subsidy-in-kind. Most societies have opted for the last alternative and provide education to their citizens at a publicly controlled institution. The argument against an unrestricted cash grant is that many citizens may "misuse" the grant and not actually expend it on education or whatever other activity the state is attempting to encourage. Vouchers, tied to educational consumption/investment use, do not have this disadvantage, although

critics have argued that many consumers may not use their vouchers "wisely" and that disreputable suppliers may actually deal fraudulently with individual consumers (the experience in the United States with the voucher-like programs under the G.I. Bill indicates this to be a legitimate concern).

How do the various rationales for public rather than private operation apply to the case of higher education? Higher education has developed from a system of private education seen to have predominantly private benefits to a mixed public and private system where social benefits are of considerable importance. If higher education were traded as a market good, the public interest would be only in those activities all societies must engage in to protect the sanctity of contracts, most notably the avoidance of fraud. Individual purchasers would be able to evaluate for themselves whether higher education actually had any effects that would be beneficial to them. The quantity and quality of information and their own ability to reason would determine the value of their decision. As in the case of normal market transactions, the cost of poor decisions would fall predominantly—if not exclusively—on the decision maker.

Once an activity is transferred from the market to state control, one encounters that bias for aggregation which is one of the most serious handicaps faced by public administrators. In education, most professionals are quick to recognize the fallacy of viewing "education" as if it were a monolithic structure, whether on an intra- or an international basis. The diversity in the type and quality of inputs, even of such crude measures as teacher and student characteristics, materials, facilities, or curricula, is such that even within a given level of education in a specific country or region, one cannot speak of "education" meaningfully as a homogeneous commodity.

The bias for aggregation can be traced to the analytical requirements for the traditional techniques of centralized administration: Even where the necessity of specific data for "individualized" collective decision-making is recognized, costs are likely to prohibit the acquisition of such data. The more distant the higher education administrator is from the individuals affected by his decisions and the more heterogeneous the population itself, the greater will be the requirement for collective artifices. Because the public administrator must make decisions for a large number of disparate individuals, he is forced to act in line with what he perceives, correctly or not, to be the *common* characteristics of the group. In the context of most planning decisions, in fact, there may be no characteristic common to all members of the population. The public administrator is then forced to fall back upon the even more tenuous decision base of his perceptions of

the majority or modal characteristics of the population. Thus, even with perfect information and perception, a policy that is administered unvaryingly to a disparate population will result inevitably in a poor fit between policy and individual needs for some portion of the affected group. The conclusion to be drawn from this is that the individual who expects a perfect solution to the problem of public versus private organization of production will rarely find a totally satisfactory solution in selecting the public alternative. The relevant question is, however, whether the public production is or is not better than private production, not whether either form of production is costless.

The policy issue to be examined here is whether one can create a logical case for public subsidization of higher education on the basis of objective investment or expenditure criteria. Before pursuing this general question, it is worthwhile to analyze the actual effects of subsidization policy. A "tax" financing vehicle is assumed even though debt financing may be the actual means of obtaining public funds for the subsidy. The effect of the debt can be treated as a form of tax incidence and thus is not a significant issue here.

Figure 1 presents a single time period diagram in which the horizontal axis represents consumption of higher education (X_1) and the vertical axis all other alternative uses of funds (X_2)—including saving. The consumer's budget line BB' (the representation of various combinations of X_1 and X_2 the consumer can purchase given his income of Y) is found by noting the end points of the line on the X_1 and X_2 axes. The respective end points are determined by dividing the price of X_1 or X_2 into the income Y . Thus, point B on the X_2 axis is found at Y/PX_2 and point B' on the X_1 axis is found at Y/PX_1 . Since the prices are fixed, a straight line connecting B and B' gives the consumer's budget line (the locus of combinations of X_1 and X_2 that can be consumed with income Y). Given the indifference curve of UU , the consumer will be optimizing his utility at point C with ON units of X_2 and OM units of X_1 (higher education).

If we now introduce a subsidy of higher education, the result is to reduce the price of X_1 . This also changes the X_1 end point of the budget line to the right since $Y/PX_1' > Y/PX_1$. The new budget line is shown in Figure 1 as BB'' . Given the new tangency to indifference curve $U'U'$, the consumer is now optimizing utility at point A. Thus, subsidization is seen to improve the utility of the individual. However, if one extends the analysis to comparative statics wherein one must consider the source of funds used to subsidize X_1 , a different conclusion is reached. The subsidy funds cannot have simply appeared—they must involve alternatives forgone for either this consumer or

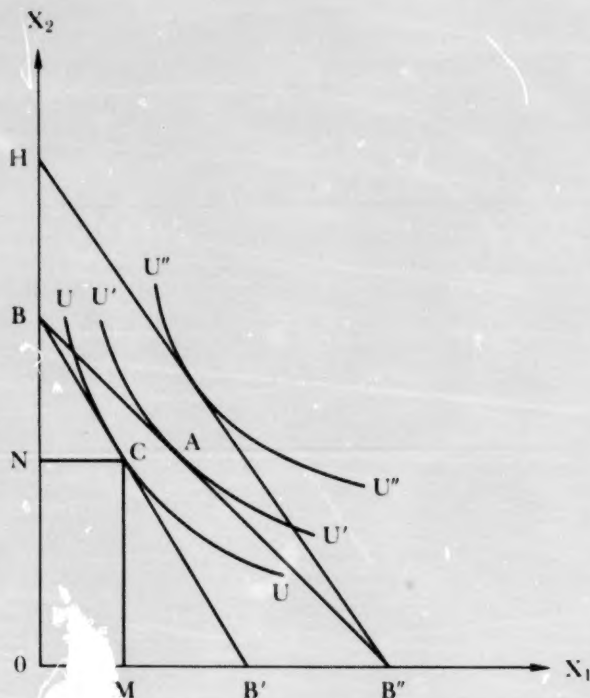


Fig. 1. A model of taxation and subsidy effects.

someone else in society. If, as is usually the case, the individual in this analysis is assumed to be the "typical" or "average" consumer, then the effect of taxing consumers to subsidize higher education can be analyzed.

The result is the recognition that the original income measure Y must have represented net income after higher education taxes were deducted. Thus, the original starting point should not have been BB' but the budget line HB'' .⁴ At this budget line the tangent indifference curve is $U''U''$, higher than either of the previously cited curves. This shows that the higher educational subsidy argument is actually only a

⁴ The pretax, presubsidy budget line must have been HB'' because this budget line is the only one that satisfies the joint conditions of possessing the original prices and the original income level. The first is indicated by the fact that HB'' is parallel to BB' and the second is indicated by the fact that it has an end point at B' .

special application of the general theory of subsidies which notes that, *ceteris paribus*, an individual would perceive any tied subsidy (or subsidy-in-kind) as inferior to receiving (or, in this analysis, keeping) income over whose spending he has full discretion.

But if taxing to provide subsidies leaves the "typical" individual in an inferior position, why do we have subsidies at all? First, the assumption within the model of an average individual whose share of tax payments is exactly equal to his share of subsidy receipts obviously does not reflect political and fiscal realities. There has been extensive discussion that, in fact, there may be significant systematic differences in the proportions of costs paid and benefits received by different social groups or income classes for such programs as public higher education (Hansen & Weisbrod, 1969; Windham, 1970; Vredevelde, 1973). Also, while subsidization may or may not result in a decline in general social welfare (if such a concept has any practical meaning), it does allow certain members of society to benefit at the expense of others. Where those benefiting are from more advantaged groups than those financing a program, the maldistributive effects must be recognized as a real policy cost of the program.

If one restricts the analysis of public subsidization to objective criteria and leaves aside the arguments of justified exploitation of one subsection of society by another, the only case for subsidization must be made on the basis of the possible unrecouped externalities that are associated with the production or consumption of the subsidized activity. While there is not room here to deal in detail with the controversy over the existence and significance of externalities (although they are treated at some length in Windham, 1976), the views of this writer may be summarized as follows (Windham, 1972):

The existence of beneficial externalities from the production of college graduates is uncertain; their manner and extent await elaboration even if they do exist; and, if they are specified objectively, they still do not constitute, by themselves, an adequate justification for public subsidies of the (higher) educational process. (p. 553)

The conclusion which follows this statement is that greater free-market operation of higher education could benefit both society and higher education in the long run. Unfortunately, the conclusion glosses over a basic assumption which, while probably applicable to many national value systems, is certainly not applicable to all.

The assumption is that, *ceteris paribus*, production should be centered in the private sector. This assumption places the burden of proof on advocates for government "intervention" into the economic system. Applied to higher education, this means that unless substantial advantages are achieved by public finance of the system, the free

market, with its allocative and individualistic emphasis, should be allowed to operate. A socialist writer, however, may insist that the burden of proof should operate in the opposite direction. This attitude is also appropriate in developing nations where the necessary capital and information systems for the optimum operation of a market-oriented educational system are lacking. As a compromise it may be suggested that public support be restricted to direct subsidies of individuals rather than institutions. Such a program assures a larger role for consumer sovereignty in the higher education market but leaves the redistributive inequities inherent in the user-nonuser problem unchanged.

Although arguments for the use of free-market processes for education can be traced back to Adam Smith and John Stuart Mill (La Nove, 1972, includes a reference in Mill's writing to a voucher-like concept), the present reexamination of user-financing of higher education stems largely from the work of Milton Friedman (1962, chap. 6; 1968). The debate on the free-market operation of higher education is complex, but two main advantages are claimed for the proposed change from predominantly public to predominantly private financing. These are the increased user-control that would result and the clearer set of incentives in the form of full costs and benefits that would face the prospective student.

In terms of the first point, it is asserted that private financing of education will destroy the extant public monopoly over higher education that exists in most nations. Even where private higher education does exist, it has suffered seriously from the difficulties of price competition with the directly subsidized institutions. It is assumed that user-financing will force universities and colleges to become more efficient in producing their product (since students can shift more easily to other institutions) and that the product itself will be more in line with what students want. Opponents to user-financing have asserted that the free-market operation of higher education would reinforce the advantage of the already well-to-do, that it would place a premium on private information which at present is inadequate or even incorrect, and that user-financing offers no more consumer effects than would a publicly financed voucher plan.

A voucher plan would operate in the following manner: The government would tax society to collect funds for higher educational support and would then, as an alternative to the present system whereby funds are granted directly to an institution or for a student's use at a particular institution, grant the individual student a subsidy of a fixed amount. This amount, which may or may not be based on some measure of financial need, could be used at any approved university or college.

However, the second advantage for user-financing—the improved specification of the incentive system—would not be achieved by the voucher approach. The proponents of user-financing feel that public subsidization operates as a subsidization of error. If the student bore a greater share of the costs of higher education, the argument goes, he would have a stronger incentive to choose a field in which the expected future supply of graduates is relatively scarce, to use his time and abilities in the most efficient manner during the education process, and to forgo higher education if the unsubsidized private returns are insufficient to justify his investment.

The opponents to user-financing counter by arguing that such a program could have disastrous effects on present institutional arrangements. They insist that the reason for subsidies is that market prices for graduates do not accurately reflect the societal valuation of different types of graduates. This is because the education of the students embodies the production of social benefits which are not reflected in the market values. This argument has been countered by noting that it would seem more efficient, *if* social benefits do exist and are relevant to pricing, to subsidize the pay for those graduates who produce such benefits than to subsidize the education of all graduates.

AN ALTERNATIVE PROGRAM OF HIGHER EDUCATIONAL FINANCE

The program to be proposed here is one that should appear revolutionary only to those who are satisfied with the performance of higher education in its present environment. The basic framework of the program consists of:

1. undergraduate tuition equal to the full instructional costs calculated separately at each public institution;
2. the creation of a quasi-public body with authority to issue bonds so as to accumulate sufficient potential student-loan funds; and
3. the granting of loans to students at full-interest expense with optional repayment periods extending to a minimum of 25 years.

Loans would be available to every full-time student in an amount equal to full tuition and special fees, a realistic maintenance allowance, and some compensation for the student's forgone earnings. The need for and the effects of each of these changes will be elaborated upon below.

The need for full-cost tuition is a result of the impropriety of implicit subsidies through the tuition charge. The reason for having tuition differentials among individual public institutions is that such a pricing system increases the ability of the student to compare private benefits and costs in his attendance decision. There is certainly good

reason why the institutions presently classified as public are not homogeneous even within a given state. This variety is a quite appropriate part of market operations, especially when attended by an adequate provision of information about the differences of quality and cost. The inadequate collection and distribution of such information are further serious problems faced by consumers of education. Also, it is inequitable to charge the average system-wide cost at each institution, because students at less expensive public institutions would pay more than their share while students at the more expensive state schools would receive a new form of subsidy.⁵

If enrollment is not to be adversely affected by increased tuition, the capital market must be simultaneously expanded. The student-loan authority would pay full market rates in selling its bonds. The requirement that the authority be self-supporting is obvious if the need for public subsidies is to be avoided.

A major innovation in this program is the elimination of the need-determination process in granting loans. As all borrowers pay full market interest, there is no requirement that the monies be restricted to the "needy." It appears legitimate to view higher education as consisting of students who are potentially wealthier than nonusers of the system. This potential wealth should both qualify them for the loan as well as remove the need to subsidize their education. It is important to note that this concept of "potential wealth" should qualify many more minority and poverty students for loans than qualify within the present capital market.

Two advantages derive from avoiding the need-determination process. The first is simply from eliminating the administrative expense that such a system involves. The second advantage lies in escaping the present unavoidable weaknesses of need-determination. Need is usually estimated by determining the contribution that a student and his family are expected to make toward educational expenses. Agencies like the College Scholarship Service and the American College Testing Program have several techniques for doing this, but they all rely primarily upon the present economic condition of the student's family rather than upon the student's lifetime-income expectations. The need-determination process, in its present form, is especially weak in that reporting of family income is not certain; the parental contribution rates appear most severe for low- and middle-income parents; the parents' willingness to pay may differ sharply

⁵ No case is made here for alternatives to common tuition policies *within* an institution that fail to adjust for cost differences among programs. It is, however, another source of inequalities and deserves attention.

from their calculated expected contribution; there is a strong incentive for the student to appear independent from his family, whether or not he is in fact financially independent of them; and the amount of the student's personal contribution from earnings is often unrealistic, especially for minority youths.

The problem of financial assistance for out-of-state students would be eliminated under a full-cost tuition plan since, with no public subsidy, there would be no reason to discriminate against them. With the removal of tuition rates that help discourage a student from going to college in another state, an increasingly heterogeneous student body might evolve. Such heterogeneity has been viewed as favorable in the past.

It may be assumed with some degree of certainty that the private benefits of higher education are sufficiently great that most if not all students will continue to avail themselves of higher education if they are able to finance efficiently the expense of such an education. Daniere (1964) has noted, however, that it is impossible to predict how students will react to new loan programs. It may be necessary for a public agency to support the loan program through repayment guarantees until the risks become more precisely determined. Reluctance to make long-term loans to college students is probably strongly reinforced by the largely negative experience in this area of the capital market to date. The most important research question that remains is the adequacy of the capital market to handle the large-scale increase in loan funds that this program would entail.

The fact exists that certain parents already have the opportunity to pay for their child's education over an extended period. In addition to equity considerations, the extension of such an alternative to all students who wish to borrow appears necessary if the reluctance toward rational indebtedness is to be avoided. Such a reluctance can be expected to be especially characteristic of low-income families.

With a financing program of the type discussed here, the public institutions of higher education would no longer be dependent on legislative grants. Such institutions would probably continue to be governed by state-appointed trustees, but this should not prevent them from being more innovative than they have been under the present system. Private colleges would gain students from the public institutions, but only to the extent that they offer programs more attractive to the prospective student. This program of tuition and loans would not be a panacea for those private schools whose problems stem from an unwillingness or inability to offer a marketable good, that is, a useful education. The private colleges that deserve (by the market test) to continue would be helped. Where other private

institutions fail, they will not be able to place the blame upon unfair price competition from the public system.

Another advantage of this program over both the present system and other suggested alternatives is that it allows greater independence for the students without totally removing the parents' incentive to help their children. A child is no longer restricted in his decision to enter college by his parents' inability or unwillingness to pay for the cost of his education. The parent is, of course, free to pay for all or a part of his child's expenses as he is with any other economic activity of the child. Those who wish to free their child of a potential loan obligation or to provide him with a higher standard of living while in college will be able to do so.

Most will probably recognize that the effect of this program would be to produce college graduates with various debt burdens and that the size of the burdens would be an inverse function to current family income. To the extent that college graduates are recipients of higher lifetime incomes this effect is less of an equity problem. It is an unfortunate fact that higher education is an institution peculiarly unsuited to egalitarian objectives. The cohort from which higher education draws students has already been biased in favor of higher income classes by the effects of the preschool environment and primary- and secondary-school experience. The fact that the proposed tuition-loan program would eventually release millions of dollars, which each state could invest in its precollege educational systems, is an important long-run benefit which should significantly contribute to the future equality of educational opportunity.

The present funds that are earmarked for scholarships and loans are demonstrably inefficient. A North Carolina study (Windham, 1972) estimated that the determinable financial-aid need for all post-secondary students in the state (public and private, four-year, two-year, and proprietary) was \$59.7 million, while \$75.5 million was available from all aid sources. Why was there still a financial-aid deficit? The problem was a result of the fact that only about one-third of the \$75.5 million of total aid was generally available on the basis of need. Thus, the present aid program, much like the implicit subsidy of tuition, gave extra funds to many who did not require them while inadequately providing for those with greatest need.

So there is little to grieve for in the passing of the present financial-aid system. Financial-aid administrators, relieved of the mundane tasks of need determination and matching grants with particular students, would be able to concentrate on the more important tasks of general financial and educational counseling.

The key points of debate which may be anticipated are whether adequate loan programs can be established to meet the needs of

present and new users of higher education and what the final long-run equity effects of the program will be. Given that large amounts of grants (either overt or in the form of tuition subsidies) already exist, the problem of supplying adequate loans should not prove unnecessarily difficult. The long-run equity effects should be favorable, as the user group consists of a more proportional representation from all income groups and nonusers are no longer required to subsidize users. The remainder of this chapter deals with how a user-based financing system of the type described here fits into the larger model of incentive-based higher educational planning.

AN INCENTIVE-BASED MODEL FOR HIGHER EDUCATIONAL PLANNING

Personal accountability is at the core of any effective system of incentives. However, one must recognize that private assumption of the costs of a decision implies a prerequisite need for equitable public structuring of decision-making. Individual decision-making is not simply a glass through which present social distortions will pass but may become a lens through which extant injustices are magnified. The results of individual accountability will be in line with the established fiscal and nonfiscal incentives; whether the motives for establishing these incentives and the effects of decisions based upon them will be "good" is a decision each individual will have to make. If one believes no change in education is meaningful until a general and medical transformation of society takes place, then an incentive-based administration of the system makes no more sense than any other kind. However, if one believes that improving rationality and explicitness in any sector of social behavior can lead to immediate allocative improvements while simultaneously highlighting the remaining distributional questions, incentive-based programs dependent upon individual accountability deserve serious consideration.

Figure 2 presents a simplified model of a higher education incentive/information system. Although errors of excessive simplification are unavoidable in any schematic of this type, the model shown here does come much closer to capturing the complexity of influences that determine educational decision-making at various points in the education-employment progression than do the aggregative models which have dominated heretofore. And yet this model attempts to avoid the inherent impotence of a totally recursive model wherein every factor is seen to affect every other factor.

The model begins prior to the higher educational process because, as is seen in the models of higher educational attainment, one of the most important determinants of the effects of higher education is the

student input. Here, all previous family, innate, and significant peer effects are incorporated with the pretertiary educational effects to produce a group of potential higher education students with a given distribution of abilities—cognitive and noncognitive. In the "market" for admission to higher education the individual students may have a free, constrained, or unitary choice of institution and field of study.

One factor that is not present explicitly in the sociopsychological models of educational attainment but that is emphasized here is the importance of the flow of information from higher education, the labor market, and research and planning activities to the individual decision-maker (student, parent, or administrator). An important research question is the amount of such information received and the degree to which it enters the individual's decision-making process. Many higher educational decisions appear to be made with little calculation of the eventual use to which higher educational attributes are to be put after graduation. It is in such a context as this that rewards and sanctions can be instituted to improve either the convergence of private with public preferences or at least the private assumption of the costs of decisions that are not consonant with public goals. If higher educational costs are heavily subsidized and students are free to choose institutions and courses of study, then a wedge is driven between the individual criteria for investment and the public criteria. The result will normally be that more individuals engage in higher education than is socially optimal at the time and they engage in courses of study that do not reflect the economic requirements of the labor market. The subsidy underwrites the cost not only of free choices but also of erroneous and even careless ones.

The incentives are further clouded if public employment policies are sending out a signal that educational specialization is meaningless in terms of employment and economic success. The work in the United States by Freeman (1971) indicated that students, even within highly but not totally subsidized higher education systems, do adjust to the signals of a relatively free labor market and change specializations to meet changes in demand. In this process they are limited by the amount and accuracy of information, its cost, their own aspirations and preferences, their time discount, and the opportunity for making discretionary judgments.

The administrator who himself must make decisions affecting the educational order of society will face the same decision calculus. However, the more distant the planner or administrator is from the actual event to be decided, the less exact and relevant will be the data base upon which decisions are made. In higher educational planning the defect in a centrally administered system of any appreciable size

works in both directions. Not only is the administrator not fully informed, but also his instructions to subordinates will become less clear the more distant they are from him. The parents and students who are making higher educational decisions (even if they are only residual decisions about acceptance of an offer of admission or how much effort to put into studies) may fail to receive or may misinterpret the administrator's actions. While these problems can be alleviated to a degree by decentralization, many governments may oppose this dilution of authority or may feel that they do not have an adequate supply of qualified personnel to allow such a devolution of command. It is paradoxical that governments fail to take advantage of the individual's decision-making ability at the personal level where decision making is easiest and then are forced to centralize the decision-making more and more because the very nature of aggregation makes the decision process more complex.

An important attribute of Figure 2 is that the analytical emphasis can be placed upon the areas of action—the "flow" arrows between the boxes—more than on the static identification of the amounts within the boxed areas. The interaction of individual supply and demand forces (controlled by the market or administered policy), the learning and attrition effects within higher education (especially their cost-effectiveness compared to alternative educational forms), the interaction of supply and demand forces in the market for graduate employment (again, whether market or publicly controlled), the findings of educational research and analysis (including the crucial tasks of auditing the patterns of graduate recruitment, pay, and promotion and detailing higher educational unit costs), and the analysis of previous policy standards where required—all of these are the research and planning tasks that this simplified diagrammatic model stresses. Obviously, the more direct control exerted by government over these activities, the more secondary will personal decisions concerning higher education become. But individual decision-making will always be important because only the individual controls his educational effort and his use of the acquired educational advantages.

From the traditional discussion of the proper role of the public sector in any economic activity, one can formulate the educational programs that government can legitimately undertake even within an otherwise competitive free-enterprise system. It may be necessary to protect students from possible educational fraud by proprietary institutions; the government may need, in an emergent economy, to create the infrastructure for efficient allocation within the labor market; and it may be necessary to sponsor research both on educational

effects and on the results from the implementation of previous governmental policy. Finally, there is one area in all economies where a crucial role remains to be played and government may well have to be the catalyzing agent: the generation and distribution of information.

Much of the information concerning education and the labor market will be casually generated and distributed and therefore be subject to error in fact as well as to inequality in incidence. A major source of casual information upon which individuals will be basing their decisions about higher education will be the working of the labor market and the resulting infrastructure of occupational rewards and status. The factors in a decision may be viewed as dichotomous: cost effects and benefit effects. The benefit effect in higher education decisions will include the immediate consumption aspects of education as well as the long-run benefits to the educated person as a consumer and family member. However, one may expect the benefits calculation for most persons to be dominated by the perceived monetary and non-monetary returns from employment.

The biases that exist in the casual labor-market information system are likely to be in the direction of overstating possible employment and pay. Even if the employment and pay probabilities are correctly perceived, one must also consider the tendency of individuals to overestimate their own chances for success.

This educational calculation can lead to especially unfortunate results when the other part of the equation—cost—is quite low. In theory, the citizen should realize that he will pay taxes in the future to finance higher education for others, but this is rarely considered in the citizen's support for subsidized higher education and is irrelevant at the margin in his personal decision to go to a college or university. With very low costs attached to the higher educational attendance decision, the normal response of students will be to attend even if probable benefits are small. Thus, the subsidization allows the student to externalize the costs of "bad" educational decisions to the public taxpayer. If the society also provides substantial employment guarantees for graduates even if their training is not actually needed or if unemployment-insurance programs exist, the student is allowed to externalize the results of his poor educational choice even further.

Poor information and educational subsidization also explain another phenomenon common to higher education: overproduction of graduates and yet continuing shortages in terms of quality and in certain specializations. If the labor-market information received by students fails to articulate the difference in demand for graduates by quality and specialization, and subsidies are generalized rather than specific to the areas of high demand, it is hardly surprising that the

graduates produced are not the graduates required. The bureaucratization of employment policies will also aggravate this problem because the pay and promotion system may not provide differential rewards in terms of quality or specialization. In this instance, the labor market is transmitting clear information; it is the employment policy itself that is counterproductive.

This discussion of the model in Figure 2 has been designed to show the complexity of the environment within higher education. Many of the factors that influence individual decisions concerning higher education may be unknown or poorly understood. Most of the factors that influence these decisions will be outside the administrator's control. But even with these reservations the administrator within higher education has a much larger variety of possible controls over decision making than has been appreciated heretofore. Costs, admission policies (aggregate limits, specific quotas for social groups and areas of study), requirements for graduation, and information about labor-market rewards are some of the main "levers" controlled by the educational administrator. The government must also consider the public sector's policies regarding employment, pay, and promotion as a variable, the aggregate flow of funds to higher education, the improvement of the labor-market infrastructure, and changes in general, as well as educational, development policy aims.

The incentive-analysis approach to administrative planning can be shown to have both a diagnostic and a prescriptive aspect. It is useful in analyzing why certain patterns of behavior exist and then in determining the redirection of educational policy to bring results more in line with larger, social policy. A final word should be said about the role of the individual decision-maker. The user of higher education operates in an environment of information signals that are either casual or deliberate. The incentive environment of higher education consists of those factors over which the administrator has direct control, those over which he has no control whatever, and those for which he has control of the transmission of information to educational decision-makers but not of its content. The administrator must make two decisions: what effect he wishes to create and what vehicle—informational or incentive—is the most cost effective to bring about the desired result.

There are two points that have dominated this concluding section. First, planning activities must be grounded in an understanding of the social economic forces acting upon *individuals*, i.e., the incentives faced by the decision makers. Second, the incentive-based model is applicable in any social or economic setting and does not require acceptance of either a capitalist or collectivist view of the world. One

thing is certain among all of the various societies and higher educational systems: Individuals will continue to react to the incentives that they perceive, and planning and administration that is not based on an active identification of these incentives and their effects is doomed to either futility or counterproductivity.

REFERENCES

- Balogh, T., & Streeten, P. O. The coefficient of ignorance. *Bulletin of the Oxford University Institute of Economics and Statistics*, 1963, **24**, 99-107.
- Becker, G. S. *Human capital: A theoretical and empirical analysis*. New York: Columbia University Press, 1964.
- Benveniste, G. *The politics of expertise*. Berkeley, Calif.: Glendessary Press, 1972.
- Bowman, M. J. Human capital: Concepts and measures. In S. Mushkin (Ed.), *The economics of higher education*. Washington, D.C.: U.S. Government Printing Office, 1962.
- Daniere, A. *Higher education in the American economy*. New York: Random House, 1964.
- Denison, E. F. *The sources of economic growth in the United States and the alternatives before us*. New York: Committee for Economic Development, 1962.
- Freeman, R. B. *The market for college-trained manpower: A study in the economics of career choice*. Cambridge, Mass.: Harvard University Press, 1971.
- Friedman, M. *Capitalism and freedom*. Chicago: University of Chicago Press, 1962.
- Friedman, M. The higher schooling in America. *Public Interest*, Spring 1968.
- Hansen, W. L., & Weisbrod, B. A. *Benefits, costs, and finance of public higher education*. Chicago: Markham, 1969.
- Harbison, F. H., & Myers, C. A. *Education, manpower and economic growth: Strategies of human resource development*. New York: McGraw-Hill, 1964.
- Jencks, C. Inequality in retrospect. *Harvard Educational Review*, 1973, **43**, 138-164.
- La Nove, G. R. (Ed.). *Educational vouchers: Concepts and controversies*. New York: Teachers College Press, 1972.
- Psacharopoulos, G. *Returns to education: An international comparison*. San Francisco: Jossey-Bass, 1973.
- Schultz, T. W. Capital formation by education. *Journal of Political Economy*, 1960, **68**, 571-583.
- Schultz, T. W. Investment in human capital. *American Economic Review*, 1961, **51**, 1-17.
- Vredevelde, G. M. *Income redistributive effects of subsidizing public higher education in Indiana*. Unpublished doctoral dissertation, University of Indiana, 1973.
- Windham, D. M. *Education, equality, and income redistribution*. Lexington, Mass.: Heath-Lexington Books, 1970.
- Windham, D. M. The efficiency/equity quandary and higher educational finance. *Review of Educational Research*, 1972, **42**, 541-560.
- Windham, D. M. Social benefits and the subsidization of higher education: A critique. *Higher Education*, 1976, **5**, 237-252.

Chapter 5

OUT-OF-SCHOOL FORMATION OF HUMAN RESOURCES

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THROUGHOUT history, out-of-school learning and training have played an important part in the formation of human resources. The fact that schooling has expanded manyfold has not obliterated nonschool learning. Indeed, the magnitude of out-of-school investments in persons has risen along with expansion in formal educational systems.

That schooling has been and is only a part of "education" is recognized by educational historians.¹ The extent and timing of postschool investments in human beings have been a core feature in the development and application of the modern economic theory of investment in human beings. An occasional economist has looked directly at one or another facet of out-of-school education and training—adult vocational education, apprenticeship, correspondence schools, formalized on-the-job training, proprietary schools (see especially Bolino, 1972). And the concept of "internal labor markets" as both learning and selection-promotion agencies has drawn increasing attention. Yet, despite all this work, the out-of-school formation of human resources has been relatively neglected until the last few years. The spate of recent popular books and pamphlets on "nonformal" education unfortunately is no more than a patchwork, lacking a clear analytical framework.

This chapter begins with some remarks about the nature of human resources and about economic criteria for their formation in and outside of schools. The second section examines assessments of the

¹ A representative selection of work over the past 10 years can be seen in the *History of Education Quarterly*.

magnitude and the time paths of postschool investments in human beings, giving primary attention to analyses of life-cycle paths of earning and their interpretation. The final section looks first backward and then forward at the nature, the formation, and the role of human resources in a broad sweep of time and space.

THE NATURE OF HUMAN RESOURCES AND THEIR FORMATION

Human resources are not finished "packages of skills" for use in a stable environment, nor do men live in such an environment. Some skills may become obsolete quickly; others are more durable. Some skills are utilized mainly in routine tasks; others provide flexibility or readiness to adapt to change and even the ability to initiate change. Some skills are widely applicable; others have a narrow range of potential use. And all along his life cycle an individual's capabilities are changing. The foregoing broad economic distinctions among skills emphasize the scope of their applicability or adaptation and creativity in the face of change and uncertainty. These distinctions are not mutually exclusive. They are fundamental for analysis of how a society functions both in the formation and in the utilization of its human resources.

Types of Capabilities

I have found the following categorization of capabilities particularly useful.

- A. Range of applicability
 - 1. General versus specialized capabilities
 - 2. Firm general versus firm-specific capabilities (called general and specific human capital in the modern theory of investment in human beings)
- B. Degree of adaptability to change and uncertainty
 - 1. Task skills versus problem-solving skills
 - 2. Learning to learn versus learning to do (or to earn)
 - 3. From "worker effects" to the "ability to deal with disequilibria"

These distinctions are as relevant in nonmarket as in market applications.

General versus specialized capabilities. The most general skills often are called "aptitudes," though they may have been in varying degrees acquired through genetic inheritance and family background, through schooling and training, and by experiences at

work. Such very general capabilities would include, for example, manual dexterity, verbal skills, mathematical skills, and capability for effective social interaction in diverse situations. At the other extreme are highly specialized skills; examples could be rolling handmade cigars, baking bread, and identifying Mycenaean pottery. There is a continuum in degrees of generality and specialization. The most general skills will not become obsolete, but many of the most specialized skills will be displaced with technological change.

Firm-general versus firm-specific skills. The term *firm* should be interpreted very broadly in this context; a particular public agency may be a "firm" and so is a particular household. On this distinction Gary Becker (1964/1975) has built an important part of his work on investments in human beings. The baker can work in many places—this is a firm-general skill; so is competence as a carpenter or a physician, and so are most secretarial and many homemaking skills. Important examples of firm-specific skills would be the effectiveness of members of a team who have come to know each other and have worked out personalized ways of cooperating in production (Rosen, 1972a), the knowledge a secretary may have of the way things are done in a particular office and of the people with whom the secretary's boss frequently communicates (and perhaps of some of the boss's idiosyncrasies), and the knowledge a mother has of her own family. Very general skills can become economically equivalent to firm-specific skills to the extent that constraints on interfirm mobility are imposed by contract or by central authority.

Task skills versus problem-solving skills. There is an important difference between the ability to carry out a clearly specified task (even one calling for great finesse and exactitude) and the competence to deal with recurrent problems—the latter I will call the possession of *know-how*. Technical know-how in this sense may not entail skill as great as that possessed by finer craftsmen; rather, it is what enables a man to "debug" a malfunctioning technical process or tune up recalcitrant machines and equipment. The more rapidly old machines and techniques are replaced, the more important this sort of know-how becomes. A quite different sort of know-how is the social-political awareness that enables a man to coax cooperation and some consensus out of recalcitrant human beings. Technical know-how is essentially universalistic and is an indispensable ingredient in economic growth. Social-political know-how has its roots in a particular human milieu; this capability, too, may be a necessary human resource in bringing about change.

Learning to learn versus learning to do (or, more narrowly, to earn). This distinction has arisen in discussions of the "nonneutrality"

of investments that human beings make in themselves over their life cycles, though it has a broader relevance (Ben-Porath 1967, 1970; Becker, 1964/1975). Early in life (whether in school or in the early working years) emphasis tends to be on investments that enhance abilities to learn; learning to learn is important, whether or not immediate earning power is substantially enhanced. Later on there is more reason for emphasizing the learning that immediately and directly affects earning power whether or not it enhances learning power. However, the capacity to learn quickly may be just what an employer is seeking, and often it is what the independent enterpriser needs most. To the extent that this is true, the distinction between learning to learn and learning to earn disappears and there is "neutrality" in the effects of human investment.

From "worker effects" to "ability to deal with disequilibria." Sometimes this is called "the worker versus the allocative effect" of schooling (or of other learning), but the dynamic thrust is brought out more clearly in T. W. Schultz's "ability to deal with disequilibria" (Welch, 1970; Schultz, 1975). The sort of adaptive, dynamic know-how that was referred to in the discussion of task versus problem solving skills is the link between "worker effects" and "allocative ability" in making decisions relating to resource inputs, to product mix, to the organization of production or service activities, and so on. The ability to grapple with change and uncertainty calls for quick learning, acquiring information efficiently, and translating it into sound decisions.

Education versus the Transmission of Information

In all of the preceding illustrations, some sort of capability was assumed. Even the simplest, most specialized task entails a skill of some sort that has become part of the person. *Education* of some sort has occurred, not merely the transmission of information. In other words, in small or great degree, there has been a person-changing process.² The importance of distinguishing between education as a person-changing process and the mere transmission of information comes out most clearly when we consider the implications of "ability to deal with disequilibria." Until the study of small Japanese enterprisers by T. K. Koh (1977), all empirical work bearing on this effect of schooling dealt exclusively with progress and productivity in agriculture. Studies in a number of countries (but especially the United States, India, and the Philippines) have demonstrated that the contributions of schooling to agricultural progress depend on the extent of relevant research; schooling makes a difference where new oppor-

² This distinction is developed systematically in Bowman (1975).

tunities are opening up and where the acquisition and interpretation of information are needed by the farmer who would take advantage of those opportunities. The value of extension work in carrying information to farmers presupposes that agricultural research has generated findings worth being communicated. An extension service may be either complementary to or a partial substitute for schooling in the transmission and interpretation of information. However, it is rare for extension services to do much to increase the ability of farmers either to interpret the information themselves or to engage on their own in systematic allocative decisions in a situation of change. Extension services are distributors of predigested information and recipes for action.

The Loci of Formation of Human Resources

There can be various ways and agencies through which men acquire the capabilities we count as "human resources," but there is an economic logic in these processes that is related to some of the distinctions we have already drawn. One way of specifying the economics of decisions for the formation of human capital is to set up analytical criteria of efficiency on the tacit assumption that private and societal benefit-cost relationships coincide; this is what will be done here. A second approach is to consider more directly the parameters of decision making by individuals and firms and to scrutinize the economic rationale of their choice—a topic that will be discussed in the next section.

The former, the societal benefit-cost orientation, was the point of departure in an earlier essay on this subject (Bowman, 1971), so comments here can be brief. The benefit-cost balance will depend on a number of considerations, some of which follow.

1. A major consideration is efficiency in the learning process: How do people most readily learn which sorts of things? Motivations can be critical here, along with prior learning and experience, and individuals will differ substantially. However, for anyone, some kinds of learning will be more difficult in a work than in a school setting, while acquisition of other sorts of skills will be difficult without some direct tie-in with work. The most general basic skills fall into the first category. Technical and social-political know-how, on the other hand, rarely can develop without learning gained partly through direct experience. The same would be true for competence in farming.

2. There are a number of time costs in following one rather than another path in the development of human resources. These time costs may be observable directly in the allocation of hours or days or years away from other activities solely to learning or teaching without any other output. But one may speak also of time-equivalent costs of

learning on the job when the production of learning and other sorts of production are joint activities and the efficiency of instructors and of co-workers in those other activities is reduced because of the presence of the learners. Time costs of these sorts have to be related to the speed and effectiveness with which the learning occurs; the economics of the situation depends in part, therefore, on the essentially pedagogical considerations noted earlier.

3. The continuous changes that are built into the modern economy require continuous efforts to counter obsolescence. But regular school systems tend to be ponderous and not quickly responsive to shifts in demands for new skills; they adapt less rapidly in timing and in length of particular sorts of specialized training than do proprietary schools—which seem often to be invisible to the academicians who write books on the economics of education. Clearly, the more specialized, the more quickly learned, and the more vulnerable to obsolescence is a particular skill, the less suitable will be training for it in regular schools. “Vestibule” training of new employees and short-courses in proprietary schools have been the main suppliers.³

4. Those capabilities that are of value only in a particular firm or agency will normally be acquired most efficiently there, and often it is only there that they can be acquired. The informal learning by the secretary about her boss and his associates, mentioned earlier, is an obvious illustration. However, not all of the firm-specific sorts of learning will be that informal, that is, merely incidental to performing one's job. There may be quite expensive programs to “groom” selected young men or women for higher positions in a firm by moving them from one place to another as they learn about each segment of the operation. Internal management short-courses are likely to have a substantial firm-specific component. Also, when there is only one firm engaged in a certain kind of production, the formalized training programs for manual workers may go far beyond vestibule types of training. Such considerations raise the question of private incentives and how far they may coincide with a societal benefit-cost balance—a topic to be discussed in attempting to assess the extent and the paths of postschool investments in people.

ASSESSMENT OF THE MAGNITUDE AND THE TIME PATHS OF POSTSCHOOL INVESTMENTS IN HUMAN BEINGS

Broadly speaking, we may distinguish two general ways in which economists have approached the assessment of these investments.

³ In this connection see the excellent work by Hyde (1975).

There are those who have concentrated on analysis of life-earning streams, and there are those who have attempted a more direct collation of evidence relating to out-of-school vocational education and training.

Earning Profiles and the Postschool Formation of Human Resources

If all learning were firm-general and if all increases in earnings over the life cycle reflected increases in productivity net of continuing investments in one's self, there would be a neat (though by no means perfect) basis for estimating the magnitude and the life paths of postschool investments in people. However, not all learning is firm-general, and gains in earnings do not all reflect the accumulation of more human capital. We might classify possible situations as follows.

1. The pure case of firm-general investments in people
2. Investments in firm-specific training shared by individual and firm, with associated sharing of returns
3. Increases in earnings over the life span attributable to increases in knowledge of what an individual or an enterpriser has to offer (not to postschool increases in human capital)
4. A pure queuing situation in which progress depends on the chances of getting into a promising queue and the pace at which vacancies open up in a hierarchy of jobs

An individual may experience several of these elements in his lifetime, but the pure cases 3 and 4 assume that he learns nothing after he leaves school, and in case 4 there is not even any connection between his capabilities (except possibly in the initial selection process), and his economic success. No one has been able to prove that case 3 or 4 is important—or that they are unimportant. However, there are good reasons for discarding case 4 when analyzing mainstreams in the life histories of most Americans. Item 3 is undoubtedly more important, though not in a pure form that is divorced from the acquisition of increasing competence. A small enterpriser builds up a reputation (for better or worse) as customers learn to know about his firm. Similarly, a "promising" young man is moved up through the ranks of a corporation as his ability to take on progressively complex and demanding responsibilities is demonstrated. In fact, there is learning not only about the individual but also by him in these processes, both incidentally with experience and through deliberate investments in the acquisition of increased competence. Initially, most of what the employer or the superior in a corporate hierarchy learns about an employee will not be known elsewhere, but with promotions and pay raises it is signaled to other enterprises as well. (So, of course, are erroneous judgments and false cues based on favoritism or discrimi-

nation.) In any case, estimates of human capital formation based on the analysis of lifetime earnings include not only what a person has learned in the postschool years but also what others have learned and have signaled about him (or her).

The first two situations listed derive essentially from human-capital theory or related versions of the recent economics of "internal labor markets."⁴ The important distinction is between firm-general and firm-specific human capital, already mentioned several times. If all learning were of the firm-general sort, the results would be fully reflected, by this model, in life-earning streams. Even if employers incurred expenses by providing training in the firm, these costs would be passed on to the employees, who will receive a wage less than what they could command in a job in which they had no training or opportunities for learning. The employees receive the difference in the invisible but nevertheless very real addition to their human-capital worth. Mincer (1974) estimated those additions, which yield higher earnings later on. By ingenious methods he arrives at an "overtake point" at which the individual receives the wages he could have commanded without any net postschool investments.⁵ A crude graphical depiction of what is involved is provided in Figure 1. The horizontal line Y_{sch} is the earning stream that would follow if there were no postschool learning beyond what was required to prevent obsolescence (if any). The curve Y_{obs} intersecting Y_{sch} is the path of observed earnings. The undiscounted net lifetime return on postschool investments is the area (A-C). The fact that people with higher levels of schooling are likely to be more able biases estimates of effects of schooling, but the bias is less serious with respect to the estimate of the area (A-C) since both Y_{sch} and the observed earnings path Y_{obs} are raised. If ability (and schooling) increases the efficiency of postschool learning, it will raise the returns to any given amount of postschool investment as well as the estimates of the magnitude of those investments.

But this is not all of what Mincer measures. When human capital is firm-specific, individuals will not accept the full costs of investments in their human-capital formation. Instead, those costs will be shared between the individual and the employer (Kuratani, 1973), and so will the returns on those investments. Mincer picks up in his estimates,

⁴ Including the work by Doeringer and Piore (1971). Their analysis of learning and promotions within the firm is consistent with human-capital theory despite common assumptions that these theories are contradictory. Essentially, Doeringer and Piore specify a subtype of the broad class of firm-specific human capital.

⁵ A critique of this and related work is included in Sherwin Rosen's (1977) extremely valuable survey of research on human capital.

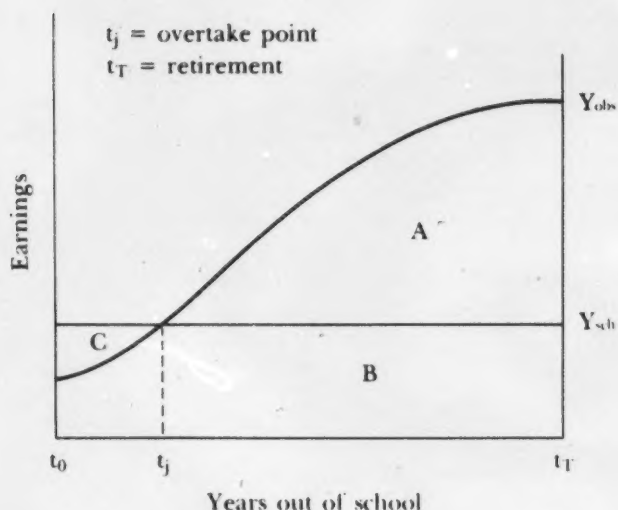


FIGURE 1. Life-earning paths with and without net postschool accumulation of human capital.

based on life earnings, the effects of all investments costed to the individual and appearing subsequently as returns to him (both firm-general and firm-specific), but he omits the portion of human-resource formation that was paid for and returns to which are recovered by the employer. Refinements aside, what we then obtain from Mincer's method as depicted in area (A-C) of Figure 1 is an incomplete estimate of the net undiscounted value of postschool formation of human resources. There is a downward bias due to the omission of investments by the firm (not passed on to the individual); there may be an upward bias insofar as the individual's progress over time is attributable not to increases in his capabilities but to increased knowledge about those capabilities on the part of his employers or of his customers.

The measurement problems that we encounter because some of the firm-specific investments are not reflected in earning streams do not end here, however. The worker who has shared the costs of such investments does so only because he assumes that there is a good bet that he will be able to recoup that investment later on from his employer. There is an implicit long-term contract, whether or not an

explicit one. Seniority provisions in union contracts play a part in this process; for individuals who climb toward higher positions the assurances are less formal (though not any less firm on that account). One result is to break the link that was assumed in Mincer's model between the time paths of human-capital formation and the returns. At the extreme, the labor market becomes a capital market in which the agreement between employer and employee can include implicit lending from one to the other. In principle this can go in either direction, and it is possible to make a case, at least, for the proposition that there may have been some lending by workers to employers under the Japanese life-commitment system; as a result, immediately before retirement the Japanese employee with long seniority will be earning more than he is at that time worth. Perhaps this aspect of seniority systems is not rare in the United States. The high earnings of senior men are part of the bargaining power by which firms attract and retain younger men of high ability and qualification who hope for and anticipate comparable returns later.

Before leaving the analysis of earning paths, a brief digression is in order on the alleged "puzzle" that earning streams rise relatively steeply at first, then level off. This phenomenon seems to have given rise to needless confusion. Some have even made the patently false assertion that the observed earnings profiles are inconsistent with a "human capital" approach in the interpretation of earning paths. Proponents of queuing theory have used flattening of the curve to support the argument that as the gap between potential attainment and starting point is narrowed, continued promotions into better jobs with higher earnings become progressively less likely. This introduces something more than simple queuing, but it sets aside as either unimportant or as not a part of the model any consideration of learning in the postschool years. Again, I reject such an interpretation for the United States. However, we could get similar results from a situation of type 3 in my classification; the process of gaining knowledge about a man does not go on indefinitely and we might expect a slowing up of promotions as the full potential of a man (but rarely of a woman) comes to be recognized.

There are also alternative interpretations within the theory of postschool investments in human capital.

First, growth of earnings may be damped by continuously pressing problems of skill obsolescence.

Second, as the human capital embodied in a man increases, the costs of his forgoing potential earnings in order to make further investments in himself rises. Unless his efficiency in formation of human capital rises as rapidly as his capacity to earn, successive investments become steadily less attractive. This is what the "neutral-

ity" hypothesis and its denial, to which I referred earlier, are all about.⁶

Finally, an important part of the investment that men make during postschool years is in the selection of a job that carries with it relatively high potentials for learning through experience. The chief theoretical model based on this way of looking at postschool formation of human capital made the simplifying assumption that some jobs carried with them a given relative learning potential indefinitely, and that individuals over time shifted from high-learning jobs to purer-earning jobs (Rosen, 1972b); employers "sell" learning opportunities to employees as part of the employment package. Taking the next step, to an assumption that is more realistic (even if awkward to "model"), it may be suggested that the marginal learning potential in a job often declines with increases in the length of time a person has worked at that job. The pace of increase in productive power would then slacken, and this would be reflected in a dampening of the rate of increase in earnings as the years go by. Measuring human resources in terms of value in use, one should expect just what is in fact observed: Earnings rise rapidly at first but slowly later on.

Whatever the caveats, estimates such as Mincer has made must be taken seriously. They provide the best available summary estimate of the importance of postschool investments in the development of human resources that are actually put to use (human-resource potentials are another matter). Using essentially Mincer's method but applying it to male wage and salaried workers in Japan as of 1966, I estimate that postschool contributions to human-resources formation were one and a half times the contributions of schooling above the compulsory levels. For white males in the United States, similarly estimated postschool investments just matched the importance of schooling. For black males in the U.S., however, postschool learning opportunities have been severely limited. It remains to be seen to what degree this situation is changing.⁷

*An Inventory of Out-of-school Occupational Education
in the United States*

Attempts to assemble more direct evidence concerning the nature and magnitude of out-of-school investments in the development of

⁶ See the remarks in the first section on learning to learn versus learning to earn. The first specification and testing of the neutrality hypothesis were by Yoram Ben-Porath (1967, 1970), who found mortality an insufficient explanation of the slowing up of growth in earnings and implicit investments before the middle years of a man's working life.

⁷ "Screening" into more and less promising career channels occurs both through schooling and by categorization of the population on other grounds (such as sex and

skills have usually been directed toward "occupational" skills in a relatively narrow sense. The learning through experience on jobs that provide greater (rather than lesser) learning opportunities is not part of such an assessment. Moreover, in seeking more direct evidence, this approach is the opposite of what we have just been discussing in that the investments are identified in terms of training inputs, rather than in terms of their effects on earning power or productivity. Nevertheless, collation of information on training inputs is itself an extremely difficult task. The most extensive effort appears to have been that of August C. Bolino (1972) and remarks here are confined to his major findings. He refers primarily to changes over time rather than to the magnitude of postschool inputs relative to school inputs into human capital at any given time. Bolino summarizes his purposes and his main findings as follows:

In determining the contribution of education to economic growth, Denison omitted occupational education because these "would have but little effect." He estimates that education accounted for 23 percent of the 2.93 percentage point rate of growth of national product from 1929-1947 and 12 percent of the 1909-1929 growth.

This research has two main objectives: to trace the development of occupational education and to recompute labor productivity by adding in the omitted types of education: adult education, adult vocational education, apprenticeships, correspondence schools, Federal training programs, on-the-job training, private business schools and special schools.

The revised labor productivity figures show that Denison understates the contribution of education by 41 percent in the period from 1900-1929 and by 20 percent from 1930 to 1957. However, if we exclude the 1930s, the understatement is 31 percent.

While maintaining great respect for Denison's work, one may not be altogether happy with national accounting interpretations of the place of education in economic growth (for reasons that will be specified shortly). However, Bolino's estimates of the relative importance of *increases* in out-of-school occupational education are impressively large. This study is notable also for insights with respect to the incentives that led to expansion (or contraction) in one or another sort of training opportunity and in responses to those opportunities over the past hundred years. That out-of-school training has been, is, and unquestionably will be of tremendous importance is well documented

race). But this does not mean that advancement is independent of human capital. Much of what happens in discriminatory practices is the screening out of opportunities to learn and especially of the more informal but often crucially important opportunities to learn by experience in successively more demanding jobs.

in Bolino's findings. The notion that the spread of schooling displaced other forms of learning cannot survive a perusal of his work, even though the details of what has been going on have changed. Equally untenable is the notion that the recent emphasis on out-of-school training represents something new—except, again, in some of its details, much of the salience of this topic is due to the fact that would-be planners and policymakers are just discovering the out-of-school sectors.

IN THE BROAD SWEEP OF TIME

In any changing society many individuals are seeking and finding ways to develop and to utilize human resources outside of the regular school system. Despite centralized controls, this is true of Russia,⁸ as it is of Japan and of the United States. Given a modicum of openness, it is true in the most dualistic as in better balanced economies.⁹ When we look casually at what is happening at any given time and place, we observe that decisions are being made within a set of constraints and among sets of alternatives that may seem to be firmly grounded if not immutable. However, the actions of today reflect earlier changes, and current decisions will in turn bring about the new conditions of a near and of a more distant future. Planners, legislators, and educational administrators can modify the incentive structures within which individuals act, but the panoply of activities in the formation of human resources that emerges when people are energized to improve their lot is much larger (and more variegated) than the highly visible actions "at the center." Difficulties of central control in the development even of formal schooling have been demonstrated dramatically in both developed and less developed nations over the past two decades; out-of-school training and learning are even more elusive.

These final remarks are confined to a few broad themes viewing human resource development in a longer span of history:

1. Human-resource formation in the face-to-face economy;
2. Some implications of scale and complexity;
3. The importance of know-how as a development dilemma.

⁸ Even the most centralized economy depends ultimately on the incentives that constrain or stimulate individual actions and on responses (often not quite what was anticipated) to the rules laid down. The numerous switches that characterized Soviet administrative measures in the Stalinist era reflect this process.

⁹ Kenneth King (1975) has given us a remarkable study of grass-roots adaptations and inventiveness in the formation of human resources in the informal sectors of the economy of Kenya.

The Face-to-Face Economy

The face-to-face economy is not just work in the small isolated village in which people all know each other. It is with us today also, but mainly as small pieces of a vast impersonal totality. Professor Torsten Hägerstrand (1965, 1967) has emphasized this theme in developing and testing his concept of "information fields." Even in the most sophisticated and complex modern societies the communications that count most come down to individual "tellings" from one person to another. This is how men and women gain access to the more informal postschool learning opportunities by which they move ahead. It has also been part of the process that has impeded (unconsciously as well as consciously) the integration of minority groups and of women into fuller participation in the upper echelons of authority and decision-making. It is partly in face-to-face interactions, not just through impersonalized assessments, that one man rather than another is selected for managerial development and by which competencies come to be assessed. Face-to-face communications of many kinds are also a key element in learning by apprenticeship, in traditional society on the one hand but also at the forefront of high-level skill formation in the postindustrial society—whether within the school system (as the PhD candidate and his dissertation supervisor) or outside of it (as in the grooming of one's corporation successor).

While there is no closer face-to-face experience than in a family, it is bypassed in this discussion of agencies of out-of-school formation of human resources because its importance in the formation of attitudes and in contributions to performance in school is so well recognized and (for better or worse) so pervasive. However, family (and neighborhood) contributions to career decisions and to the formation of human resources require our attention in a more specific context—not just as a part of the broad process of social acculturation, but in relation to occupational "inheritance."

The most familiar case of occupational inheritance is in farming, with or without inheritance of the farm: Few men who are not sons of farmers or who did not at least grow up in a farming community become farmers. Only those men possess the kinds of "human capital" that are of special relevance for farming; they have acquired that knowledge at minimal cost. Similar considerations apply, though in a less extreme form, to the "inheritance" (again direct or indirect) of nonfarm proprietorships or the participation in partnerships. The human capital in such cases also may have specialized components; helping one's parents run a family grocery store or an inn is an obvious case. Less obvious or direct is the learning of what it means to

be a physician when one is the child of a physician. With broader definitions of learning for "occupational inheritance" one might include something so general as the learning of how to work with things, the acquisition of ease in such manipulations as may be acquired by working alongside a craftsman even if one does not later follow that craft. But, as we all know, few sons today observe their fathers at work; today the face-to-face economy is mainly outside of the family and it has little direct linkage with childhood or adolescent experience.

Scale, Complexity, and the Educational Mix

The increase in the scale and complexity of modern societies may have brought us higher levels of living, but it has its costs and its special demands on human resources. Despite the survival and recreation of face-to-face communication, impersonal communication has burgeoned. Need for such communication in turn calls for skills in the storage, retrieval, and transmission of information; the computer is just the latest step in this evolution. The more formal parts of the educational system and schools in particular have been the major agency in preparing people to participate in this impersonal communication system. The increased supply of people so qualified contributes to the development of yet more formal communication (even in invented languages) and reinforces demands for formal education. Throughout this chapter the importance of learning to learn in a dynamic world has been stressed, but even if there were little change in the aggregate, the present economic system requires a large establishment of people manning (more often "womanning") the information system. It is not surprising that Fritz Machlup's (1962) estimates of the size of the knowledge industry were so large.

The development of large-scale and complex formal systems of communication to undergird the modern way of life affects the educational mix in many details, not just by the demands made on the regular school system. One of the oldest of the out-of-school supplementary educational activities has been the provision of special clerical skills. These may be taught through correspondence or in short courses, often as part of the galaxy of metropolitan proprietary schools. Some schools are established by firms engaged in other activities, whether to train men they will employ directly or to develop human resources who will be a market for their products. IBM's programs for computer training are a striking example. More closely linked to the firm and more firm-specific in that sense are programs to train those who will sell and repair products—ranging from life insurance to vacuum cleaners. Just to leaf through a metropolitan

telephone directory to inventory the many sorts of "schools" can be an eye-opener, even though these lists are far from complete and the important in-house "schools" for employees of large corporations will not be found in these pages.

Development and Acquisition of Know-how

Know-how has been defined here as the ability to see why things are not working properly and to get them back on track. This could be technical-mechanical know-how. It could be sorting out the anomalies that have distorted accounting in a business firm. But the first dilemma of early industrialization among latecomer countries is unquestionably gaps in the middle range of skills and know-how on the more technical side. There is a fundamental asymmetry in the potentials for human-resource development relative to economic development.

In time, schooling can easily lead development in human resources, because to turn out school graduates does not depend upon or require participation in or observation of production processes. By their very nature, schools are isolated from "work"; this is their advantage as well as their limitation. The mistake that people make all too often in talking about "what is wrong" with the schools is to assume that schools can substitute for all other agencies of learning, including the home and the work place. The only real limitation on schools in leading development is a limitation in the ability of the society to pay for the schools. This fact has become clear even to the most reluctant observer during the past decade in most of the Third World. When England industrialized, limited schooling was probably a drag on development; it followed rather than led. In most countries today, though not in the poorest, schooling may be leading development¹⁰—partly because schooling has become a fashion, but also because this is where individuals see a road into the "modern sector" of a dual economy.

There is unquestionably a close connection between the difficulty of developing and diffusing know-how in a population and the emergence and persistence of economic dualism. Without intermediate skills and a fair admixture of "know-how," enterprises that would use such skills will have difficulties. One of the results is the tendency to circumvent the skill gaps by introducing ultramodern laborsaving methods of production in the formally organized sectors of the economy while "cheap labor" persists elsewhere. But this means

¹⁰ See Dore's discussion of "The Diploma Disease" (1976) in connection with schooling among populations of early- and latecomers to industrialization.

that the opportunities for development and diffusion of skills at work are correspondingly limited. Lack of intermediate technical (and managerial) skills and the know-how to resolve day-to-day problems blocks the establishment of production units in which those capabilities are best formed and diffused.¹¹

Perhaps Japanese development is not such a miracle as it may seem. The life-commitment system does provide for a high order of internal flexibility in human-resource formation, in occupational mobility, and in the countering of obsolescence. But success today goes back to the fact that the cords that might have bound Japan into an older "vicious" circle of know-how were cut in the Meiji era. The Meiji government brought many experts into Japan, paying them at foreign rates plus premiums to attract and hold them during the period needed to launch new enterprises and to train workers at various levels of the organization. Initially these enterprises were heavy losers and heavily subsidized by the state. When the burden of carrying them seemed too great, amidst threats by inflation and rising debt (though nothing like the debts of governments in less-developed countries today), the Meiji government sold the new enterprises at bargain prices to sons of the samurai. The more successful of these enterprises, now in private hands, became the powerful Zaibatsu. Whatever may be said of them and of their postwar successors (despite the "breaking up" of the Zaibatsu just after the war), these became large training, as well as producing, agencies—through both informal, indirect training and more deliberate and purposeful policies of personnel development.

There is another feature of Japanese history, this time of postwar history in particular, that is especially illuminating with respect to the nature of human resources and their utilization. In the conventional modes of national-income accounting that follow the path set by Denison in his significant contributions to this subject, the estimates of "contributions of education to growth" turn out to be slight in postwar Japan—even in absolute percentage growth points. (The *proportion* of economic growth explained by "education" is of course even smaller relative to other countries, given the high growth rates experienced by Japan.) But these results reflect the theory implicit in national-accounting conventions applied to analysis of growth. What "education" contributes is measured by the product of education-earning differentials (reduced to allow for "ability") and the increase in schooling per member of the labor force over the time period under exami-

¹¹ Several of these problems are discussed at some length under the title "From Guilds to Infant Training Industries" (Bowman, 1965).

nation. In Japan, as in many other nations, the national stock of human resources was very much underused relative to its potentials. The rapid pace of investments in physical capital in the 1950s and 1960s was possible because the complementary human resources were at hand, both in what schooling had contributed to learning efficiency and in a core of technically skilled men from which it was possible quickly to develop and to expand the supply of know-how essential for success. Whether the growth is attributed to the new physical investment or to the available under-utilized stock of human resources is a quibble. The Japanese experience demonstrates that vast human-resource potentials embodied in a population can and do go unused—what they contribute to growth depends on other factors, but the reservoir of such resources may determine how rapidly an economy can move ahead given favorable conditions and a dynamic thrust. Economists can construct various sorts of *ex-post* "aggregate production functions" to "explain" growth, but the meaning of "long-term equilibrium" itself becomes empirically elusive when what human beings do and might contribute is brought into the picture.

The main themes of this chapter may be summed up as follows:

- 1 The high visibility of schools and the involvement of governments in school systems have led to biased perceptions of how human resources are formed—specifically, failure to appreciate the importance of out-of-school agencies in human-resource formation. One of the consequences has been an unrealistic tendency to expect schools to do things for which they are ill-adapted. This has been unfortunate both for the schools and for the society.

2. Learning in school and in various out-of-school situations is in the main complementary, not substitutive: An increasingly complex economy with a sophisticated formal communication system requires increasing amounts of training in skills that can be well taught (and may be best taught) in schools, but the know-how needed to operate a complex society requires also extensive learning—formal and informal—at work. Out-of-school learning has been, is, and will continue to be of crucial importance for the functioning of a progressive economy.

3. The steepness of profiles of lifetime earnings reflects postschool investments in the acquisition of productive capabilities, the sharing of those investments between individuals and employing agencies, and sequences in the acquisition and communication of information about an individual's capabilities. Despite the considerable attention given in recent years to paths of earnings over the postschool years and to "internal labor markets," we have only begun to sort out the determinants of variant earning paths.

4. Both the economic returns to schooling and the nature and extent of what people learn outside of school depend on the structures and functioning of labor markets and the pace of innovative investments. But how labor markets operate and the capability for innovative investment depend in part on what human resources are available to support change. Policies that foster a rounded development of human resources, widely diffused through a population, will be fully as much indirect as direct. Whatever encourages innovative performance and the pursuit of excellence in economic life will stimulate both formation of human resources and their more effective utilization.

REFERENCES

- Becker, G. S. *Human capital*. New York: National Bureau of Economic Research, 1975. (Originally published, 1964.)
- Ben-Porath, Y. The production of human capital and the life cycle of earnings. *Journal of Political Economy*, 1967, **75**, 352-365.
- Ben-Porath, Y. The production of human capital over time. In W. L. Hansen (Ed.), *Education, income and human capital*. New York: Studies in Income and Wealth, NBER, 1970.
- Bolino, A. C. *Occupational education as a source of economic growth*. Report to the Manpower Administration under research grant 91-11-72-75, November 1972.
- Bowman, M. J. From guilds to infant training industries. In C. A. Anderson & M. J. Bowman (Eds.), *Education and economic development*. Chicago: Aldine, 1965.
- Bowman, M. J. Decisions for vocational education: An economist's view. In C. J. Schaefer & J. J. Kaufman (Eds.), *Vocational education: Social and behavioral perspectives*. Lexington, Mass.: Heath, 1971.
- Bowman, M. J. *Rural people and rural economic development*. Paris: International Institute for Educational Planning, 1975.
- Doeringer, P. B., & Piore, M. J. *Internal labor markets and manpower analysis*. Lexington, Mass.: Heath, 1971.
- Dore, R. *The diploma disease*. Berkeley: University of California Press, 1976.
- Hägerstrand, T. Quantitative techniques for analysis of the spread of information and technology. In C. A. Anderson & M. J. Bowman (Eds.), *Education and economic development*. Chicago: Aldine, 1965.
- Hägerstrand, T. *Innovation diffusion as a spatial process*. Chicago: University of Chicago Press, 1967.
- Hyde, W. D. *The metropolitan proprietary school*. Lexington, Mass.: Heath, 1975.
- King, K. *The African artisan*. Edinburgh: University of Edinburgh, Centre of African Studies, 1975.
- Koh, T. K. *Education, entrepreneurial formation, and entrepreneurial behavior in Japan*. Unpublished doctoral dissertation, University of Chicago, 1977.
- Kuratani, M. *A theory of training, earnings and employment: An application to Japan*. Unpublished doctoral dissertation, Columbia University, 1973.

- Machlup, F. *The production and distribution of knowledge in the United States*. Princeton, N.J.: Princeton University Press, 1962.
- Mincer, J. *Schooling, experience and earnings*. New York: Columbia University Press, NBER, 1974.
- Rosen, S. Learning and experience in the labor market. *Journal of Human Resources*, 1972, **7**, 362-342. (a)
- Rosen, S. Learning by experience as joint production. *Quarterly Journal of Economics*, 1972, **86**(3), 366-382. (b)
- Rosen, S. Human capital: A survey of empirical research. In R. G. Ehrenberg (Ed.), *Research in labor economics* (Vol. 1). Greenwich, Conn.: JAI Press, 1977.
- Schultz, T. W. The value of the ability to deal with disequilibria. *Journal of Economic Literature*, 1975, **13**(3).
- Welch, F. Education in production. *Journal of Political Economy*, January/February 1970, **78**.